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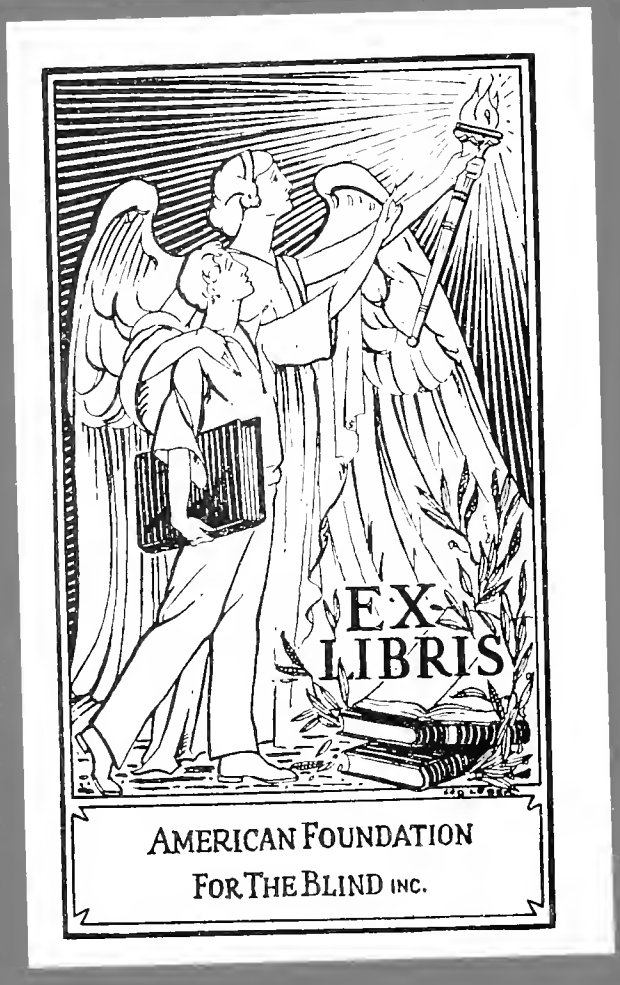

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TIME EXPANSION OF ULTRASONIC ECHOES AS A DISPLAY METHOD IN ECHOLOCATION*

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In an effort to help blind persons move swiftly and safely through their environment, a number of devices have been constructed during the past two decades. These devices are commonly referred to as mobility aids. A useful mobility aid must obtain the information needed by a blind person for safe travel and present it to him in a manner that will allow reasonable speed and versatility in travel. It is the purpose of this thesis to consider certain aspects in the design of a mobility aid for the blind.

DESIGN FACTORS

Numerous factors must be considered in the design of a mobility aid. These problems may be classified into at least four categories which may be used to identify the information, the display, and the psychological and technical problems encountered in any mobility aid device design.

The information category includes the problems of determining what information it is necessary and/or desirable to give a blind person in order to permit safe, swift, and versatile travel ability. This category may also include the selection of the mode by which the necessary environmental information is collected--that is, the choice of energy used to obtain the required information. For example, a sighted person most usually uses visible light for orientation during travel.

The display category includes the problems of imparting to the blind traveler the information made available by some energy source. A method must be used that presents the data in an intelligible, rapid, and pleasant manner. Processing information obtained by the energy source will depend to a large extent on the input mode chosen. The processing will be quite different if the input mode is the ear, not electrical shock.

When interaction between man and machine is as close as it is in a mobility aid device, problems that are primarily psychological in nature will be prominent. Several such considerations are the learning period required to operate the device successfully, interference of the device input with other channels of information, and conspicuousness of the device. Most blind persons want a mobility aid device that does not attract too much attention.

The problems included in the technical category are those concerned with the actual instrumentation and construction of a mobility aid device.

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MOBILITY AND DEVICES: WHAT DO WE KNOW?

In the following paragraphs some indication will be given of what is known and what is not known about mobility aid devices. One fact that will become apparent is the great interrelationship among considerations in each of the foregoing categories. A good place to start in the design of a mobility aid is to answer the question "What information must a blind traveler be given so that he may move through his environment safely, swiftly, and surely?" Mobility differs from other tasks which blind persons are required to perform in that it is dangerous. Unfortunately, there never has been a rigorous inquiry into the requirements for successful travel by the blind (9). For purposes of instrumentation design and scientific inquiry, a device should detect and locate obstacles, determine terrain changes precisely, give sufficient detail about the environment in order to determine precisely where one is, and provide a mental map for navigating effectively from origin to destination (9, 12). Statements of blind individuals indicate that, although fear of injury from collisions or falls overshadows all else, the major difficulty in foot travel is in maintaining general orientation in walking a straight line and in finding and identifying familiar objects (12). The blind are primarily concerned with the physical harm that results from inadequate adjustment when objects are encountered. The frequency with which objects are encountered is of secondary importance (33). Because of these considerations, mobility aid devices are sometimes referred to in the literature as obstacle detectors or guidance devices (4, 6).

A survey for the Committee on Sensory Devices (33) sought to determine the information a guidance device might be required to obtain. Blind informants were asked to note and record for a period of two weeks the kinds of objects involved in their daily collisions. All items in group A received unanimously the highest rating as being the most troublesome or dangerous. Groups B, C, and D decrease in assigned importance as well as their unanimity.

Group A

1. Crossing streets safely
2. Adequate warning of the edge of a platform
3. Mail boxes
4. Open manholes
5. Open cellar doors

Group B

6. Telephone and light poles
7. Curbs

8. Doors half-open

9. Pipes or ropes at head level; awnings

10. Stairs; detect presence of step-down

11. Difference in curbs; low on one side of the street and high on the other

12. Mantlepieces

13. Beams at an angle to the wall; flying buttresses

Group C

14. Stands on the street

15. Finding entrances of stores—that is, doorway entrances

16. Sawhorses

17. Hydrants

18. Half-open drawers

19. Ropes, chains

Group D

20. Walking straight

21. Refuse boxes

22. Small tables

23. Chairs

24. Footstools

Many tests indicate that blind persons require information only about obstacles that are less than 15 feet from them while they are walking, and that further information tends to confuse them (22, 23, 33). Thus there are three types of information that any mobility aid device should provide a blind traveler. The device should detect any obstacles or impediments to safe travel that lie in the traveler's path, and it should identify these obstacles and indicate their position relative to the device user.

Given some indication of the requirements of a mobility aid, it is pertinent now to ask what devices are currently being used. The three that come immediately to mind have proven to be the most useful to the blind traveler, namely, the cane, the dog, and the human guide. The main limitations of a cane are its lengths and rate of exploration which will not ensnare the user or antagonize bystanders (6). The effectiveness of the dog depends chiefly on rapport between dog and master, and this, like the finest of human friendships, is a rare thing (6). Fewer than 1,500 people in this country use a dog guide, although it is estimated that there are 30,000 to 50,000 able-bodied blind persons (32). A human guide is certainly an effective mobility aid when available, but a guide may not always be handy.

Because of the serious limitations of what are currently the most successful devices, a real need still exists to provide the blind with more effective methods of mobility. Much research has been done in this area but, as will be indicated below, the problem is far from solved. Returning to the information category, now that some indication has been given of the information that a guidance device should provide, a decision must be made as to the energy source that will be used to search the environment. The various types of radiation that have been used in guidance devices are audible sound, ultrasound, radio frequencies, visible light, infrared, and ultraviolet light.

Audible sound-source devices radiate sound energy in the range of human hearing. They attempt direct improvement in the obstacle sense, or "facial vision," that is often attributed to blind persons. It has been known for a long time that some blind persons are able to avoid relatively large obstacles with considerable success without the use of any type of guidance device. Many blind people said that when approaching an obstacle they felt a pressure on their face. Hence, the ability became known as "facial vision." In the early forties a series of classic experiments was begun at Cornell (7, 24, 31); they proved conclusively that facial vision is accomplished by audition. Almost all audible sound devices use the auditory system as a direct input. The device emits audible sound energy and the blind user listens for returning echoes. Thus the display problem is readily solved. The device can be made comparatively simply. However, there are several serious disadvantages to an audible sound-source device. It cannot be used in noisy or congested areas and an audible output attracts attention. There is no warning of step-downs. The hearing channel, which is often needed for other purposes, is tied up. In the construction of audible devices it has proven to be very difficult to shield the user's ears from the sound source. That such shielding is essential has been shown by Welch (30).

The next energy source that may logically be considered is ultrasonics-high frequency sound energy. The remarkable success that bats and porpoises have achieved in acoustic orientation using ultrasound is currently being intensely investigated (17, 18, 27, 29). Griffin uses the term "echolocation" to refer to the process of detection and orientation by the emission of sound energy and interpreting the returning echoes (10). Because ultrasonic devices use frequencies above the range of human hearing, they require some type of processing of the returning echoes before the information may be presented to the device user. This, then, involves display and technical problems. To compensate for the increased device complexity necessary with ultrasonic devices compared to audible devices, it is possible to obtain better resolution and to have a device that will attract relatively little

attention; ultrasound is inaudible. Better resolution is possible because sound waves will be reflected from solid objects that are comparable in size with the wavelength used. The fact that echo processing is required should not necessarily be considered a disadvantage. Some processing may be necessary and desirable in order to present the selected input faculty with information in the most advantageous form. If audible source devices use any input other than the auditory, some processing is then required. Hence ultrasound is used rather than audible sound whenever the input mode is other than the auditory system. Even when the auditory system is used as the sensory input, it is not clear that it is being used in the most effective way by simply listening to echoes directly. Some processing might still be desirable in order to utilize fully the marvelous capabilities of the ear.

By far the most serious disadvantage of the current ultrasonic devices is that they are unable to detect a step-down. Specularity effects are also a problem. Some surfaces act like mirrors at ultrasonic frequencies, with the result that a smooth wall may fail to give any detectable echo at all, unless the device is pointed directly at it. Despite these difficulties many attempts have been made to develop ultrasonic devices (4, 5, 15, 22). An ultrasonic device of considerable promise is currently undergoing extensive field tests (15).

Visible light as an energy form has been used in several devices. Both active and passive light devices have been constructed. An ambient light device has been constructed in which the range is determined by automatically locating the distance behind a lens at which the image of the obstacle is in sharp focus (14). Active visible light devices radiate energy into the environment.

With visible light devices specularity is not a problem. They are also potentially capable of detecting a step-down. However, it has been a general characteristic of visible light devices that a single channel has a very small beam width (1 deg). Thus much scanning is required. Rain and fog adversely affect performance. The technical problems of providing adequate environment information and useful range information have proven to be difficult.

Although devices using electromagnetic energy of radio, infrared, and ultraviolet frequency ranges have been constructed (5), these energy forms have not been successful compared to the forms discussed above. Generally, they have been subject to the same limitations as the light devices.

Selecting a sensory input through which the acquired information may be given to the device user is a problem of no less and perhaps greater magnitude than that of selecting an energy source. The manner in which the information provided by an energy source should be processed so that the data may be displayed to the sensory input in the most effective way is a largely unsolved problem.

Some of the requirements in the selection of a sensory avenue are severe. The differential sensitivity of the organ must be sufficient to distinguish the quantitative steps within the range of information desired. The organ must not adapt or become insensitive under continuous stimulation. The signal should require a minimal effort of attention and should produce as little fatigue as possible. The reception of the signals should not interfere

seriously with normal use of the senses in other ways. The stimuli should consist of a series of clearly distinct steps except where a perception of change alone is the primary requirement. The signal should be pleasing or at least not disagreeable (12).

For a sound, some primary variables are pitch, loudness, time interval between tones, and combinations in harmonic, melodic, and rhythmic patterns. The ear has a range of about 20 cps to 20 kcsec, but success in auditory echolocation has been reported using pulses of mixed frequencies above this range (1). Negative adaptation is negligible. The intensity range that the ear responds to without pain is over 100 db. The differential threshold for intensity varies with frequency and intensity but can be as low as 0.5 db at 100 cps and 60or 70 db above threshold (13). The auditory system is capable of detecting interaural time differences of a few hundred microseconds (13).

For the sense of touch the variables are intensity, locus, and spatial and rhythmic patterns. The number of steps in intensity discriminable on stimulation of an area 1 sq mm within a range that does not elicit pain is not more than 50. The pattern of a number of points applied to the skin simultaneously is distinguished with difficulty and only simple and greatly differing geometrical forms can be recognized. The direction and distance of moving contacts on the skin can be appreciated with considerable accuracy. No quantitative studies of this ability have been made, but it appears to offer the best means of purely tactile recognition of form (12). In general, the tactile sense has the disadvantages of low spatial discrimination, physiological fatigue factors, conditioning, and inconvenience (32).

Other sense modalities that might be considered are taste, smell, thermal sensitivity, pain, and the postural senses. However, each of these senses has the disadvantages of low sensitivity, adaptation, and inconvenience.

Electrical stimulation of the visual parts of the brain has been suggested as a possible means of giving visual information (9, 12, 21). It seems clear, however, that any attempt of this sort in the near future will be unsuccessful (12, 32). The physiological and technological problems of such a method are still unsolved. The optic nerve contains about 1.5 million fibers that have essentially the same physical properties and are irregularly intermingled within the nerve. Where the retina has been destroyed, as in the greater number of cases of blindness that cannot be treated surgically, the optic nerve undergoes degeneration and is inexcitable (12). Recent work by Hubel and Wiesel (20) concerning receptive field in the visual cortex may be a start toward the future use of this sensory input possibility.

Some problems that are psychological in nature have been mentioned above. An important one not specifically mentioned is that of learning to use a device. Many devices have failed because they did not provide information in a form that could be readily learned by the user. Often the data have been in a form so complex that enormous concentration was required to interpret them (24). Other devices with very simple inputs have failed to give enough information to the user. Thus the input data should be in a form that can be relatively easily learned and interpreted. There should not be too much or too little information.

Technical problems in device construction are largely those involved with the energy source emission and the instrumentation of proper receiving and processing equipment.

Factors that must also be considered are size, weight, reliability, ruggedness, and purchase and maintenance costs.

PURPOSE OF THIS THESIS

As discussed above, a mobility aid device should provide the user with information concerning obstacles in the traveler's path, the identity of these obstacles, and the relative position of the obstacle and the user. It should display this data in a manner that can be readily interpreted and acted upon.

Ultrasound has proven to be an energy form particularly adept at detecting the presence of obstacles. Two mobility aid devices that use ultrasound as an energy source are currently being evaluated (15, 21). The preliminary results indicate that these devices are able to detect all obstacles in a traveler's path except a step-down. Both devices use an auditory display. The Russell device (21) transmits a 1 msec pulse of 40 kc sine wave. The device then observes the returning echoes and emits an audible sound whenever an obstacle is detected within a range of 16 ft from the device. This total range of 16 ft is divided into four equal divisions. The device emits four different sounds that can be readily discriminated, and one of these distinctive sounds is associated with each range division. Thus the sound that the device user hears indicates the range to the nearest obstacle. This device therefore gives no indication of the obstacle identity.

The Kay device (15) emits ultrasound that is swept linearly from 60 kc to 30 kc in 400 msec. The display is aural. Returning echoes are beat against the outgoing source sound, thereby creating an audible difference frequency. This difference frequency, which depends on the distance to the obstacle detected, is displayed to the device user's ears. Therefore, distance is indicated by the frequency of sound that the traveler hears. With the Kay device it is also possible to obtain some type of object identity information. Since the device uses a relatively narrow beam (10 deg at 50 kc/sec), some information is obtainable by scanning. Another identity clue is intensity—hard, smooth surfaces return a stronger echo than rough surfaces, and the signal intensity given to the ears is therefore louder in the first case. In practice, however, it has been found to be quite difficult to identify objects using the Kay device (8).

The two devices just discussed represent two major types and the most recent developments in ultrasonic mobility aids. Both provide interesting distance and detection information. However, the Russell device provides no identity information, and the Kay device provides only very minimal identity data. Devices using source energy other than sound have not been able to provide object identity information without an excessive amount of scanning. Therefore a need exists for a device that will display the identity of an object in an easily recognizable and rapid manner. It is the purpose of this thesis to investigate a display method that may be used in a mobility aid device and that will provide obstacle identity information.

Ultrasound was used as the energy source for this investigation because of the advantages previously discussed and because several reasonably successful devices utilizing

ultrasonics have shown that this energy form is capable of detecting most obstacles of interest. The auditory system was chosen as the sensory input because of its great versatility.

As mentioned previously, some processing of the echo information is necessary before the data may be given to the blind traveler, because ultrasound is inaudible. One possibility is to record the ultrasonic echoes in some manner and then play the recording to a listener at a speed slower than the initial rate. This will have the effect of lowering the frequency of the recorded echoes and expanding the recording in time. For example, a 1 msec pulse of 40 kc/sec sine wave recorded on magnetic tape at a tape speed of 60 inches per second (ips) becomes a 32 msec pulse of 1.25 kc/sec when played back at 1 7/8 ips. By this technique the echo information may be brought into the audible range. The display will then contain all the temporal, frequency, and intensity variations of the original echoes. The object of this thesis was to perform an exploratory investigation of this display mode and to indicate whether it might be a useful method of providing object identity information.

Two factors made such a display mode seem attractive. First, when an ultrasonic sound pulse was used as an energy source, it was possible to observe considerable structure in the echoes from various objects when the echoes were displayed on an oscilloscope screen. Second, the display method proposed retains all of this structure. Whether the auditory system could interpret this type of display was the basic question to be investigated.

ECHO IDENTITY EXPERIMENTS

In attempting to explore the questions just raised, a problem immediately arises. What type of source pulse signal should be used to produce the echoes? Several possibilities suggest themselves: a swept-frequency pulse (bat-type signal), a click (very wide band), and a burst of sinusoid (easily instrumented). The results of any investigation might depend greatly on the particular source signal used.

During an early part of this investigation, the Russell device described in the preceding section was available for use by the author. This device produces a burst of 40 kc/sec sine wave of approximately 1 msec duration. The shape of the pulses are roughly gaussian. In a preliminary test the echoes from various objects were recorded on magnetic tape using this device as the energy source. John K. Dupress [then] of the American Foundation for the Blind and the author then listened to the slowed-down echoes. Mr. Duppress, who is very familiar with mobility aids of all types, expressed the opinion that many of the objects used for these preliminary tests could be identified by their echoes. Because of this encouraging result and because this type of source pulse could be easily produced with available equipment, it was decided to use a 40 kc/sec sinusoidal pulse of 1 msec duration during the echo identity experiments that were subsequently performed. A further discussion of signal design is given in the next section.

The experiments described below were explorative in nature; the purpose was to investigate gross effects relating to the information display scheme proposed. The results

tend to be more qualitative than quantitative because at the start of the investigation it was not clear what aspects of the problem were worthy of precise psychophysical methodology. Consideration of conditions that might occur in the actual use of a device utilizing the display method herein proposed often superseded considerations of precise psychophysical design.

Experiment A: The purpose of the first experiment was to investigate whether the echoes from a few different types of objects provided sufficient information, when displayed in the manner proposed, to allow subjects to identify the objects correctly. The echoes from four objects were used. It was felt that subjects could be expected to remember four echoes after a very short learning period. The objects chosen were a bush, a person, a stool, and a wastepaper basket. These objects are items that a blind person may wish to identify for purposes of orientation and convenience. In this sense they are practical objects. Also, the objects have rather different geometries and a useful device for object identity purposes would certainly be expected to distinguish among them.

Echoes were recorded from these four objects in an anechoic chamber using an experimental setup that is diagrammed in Figure 1. Recording conditions for the echoes are listed in Table 1. The source speaker produced 40 kc/sec pulses of 1 msec duration at a repetition rate of 20/sec. The source was placed on a stand approximately 3.5 ft above the floor. This is the height that a source held in the hand might have. For purposes of this experiment all objects were placed 4 ft in front of the source on a large plywood board used to simulate the floor. The echo receiver was placed within 2 in. of the source transducer because in a practical device the source and receiver would probably be arranged together and held in the same hand. The received signal was put through a high pass filter with a low frequency cutoff of 20 kc/sec. This was done to eliminate low frequency noise. In recording the echoes, attempts were made to eliminate echoes other than those directly from the object and floor (for example, echoes off the back and side walls). Also, shielding material was placed between the source and receiver in an effort to eliminate the recording of source pulses. The source transducer was aimed at the center line of the target objects. The voltage applied to the transducer was then adjusted so that the echoes were approximately equal in peak amplitude as observed on an oscilloscope. Recordings were made at a tape speed of 60 ips.

The form of these echoes is roughly what might be expected by considering the object geometries. In the echo from the wastepaper basket a small beginning pulse came from the basket rim, a second echo from the side of the basket by way of the floor, and a third part apparently came from sound that was reflected several times inside the basket. On listening to this echo the last pulse sounded like striking a hollow pipe.

The same two subjects were used in all experiments to be described in this section. Both subjects had normal audiograms and normal vision. Neither had ever participated in psychophysical experiments before, but one subject had received considerably more musical training than the other. She felt that this training was helpful during the experiments. All experiments were conducted with the subjects in a soundproof room. The stimulus was given to both ears through earphones, and the stimulus intensity was adjusted to a comfortable level as indicated to the experimenter by the subjects. The signals were taken from the tape recorder, amplified, and applied to the subjects' earphones without intervening filtering.

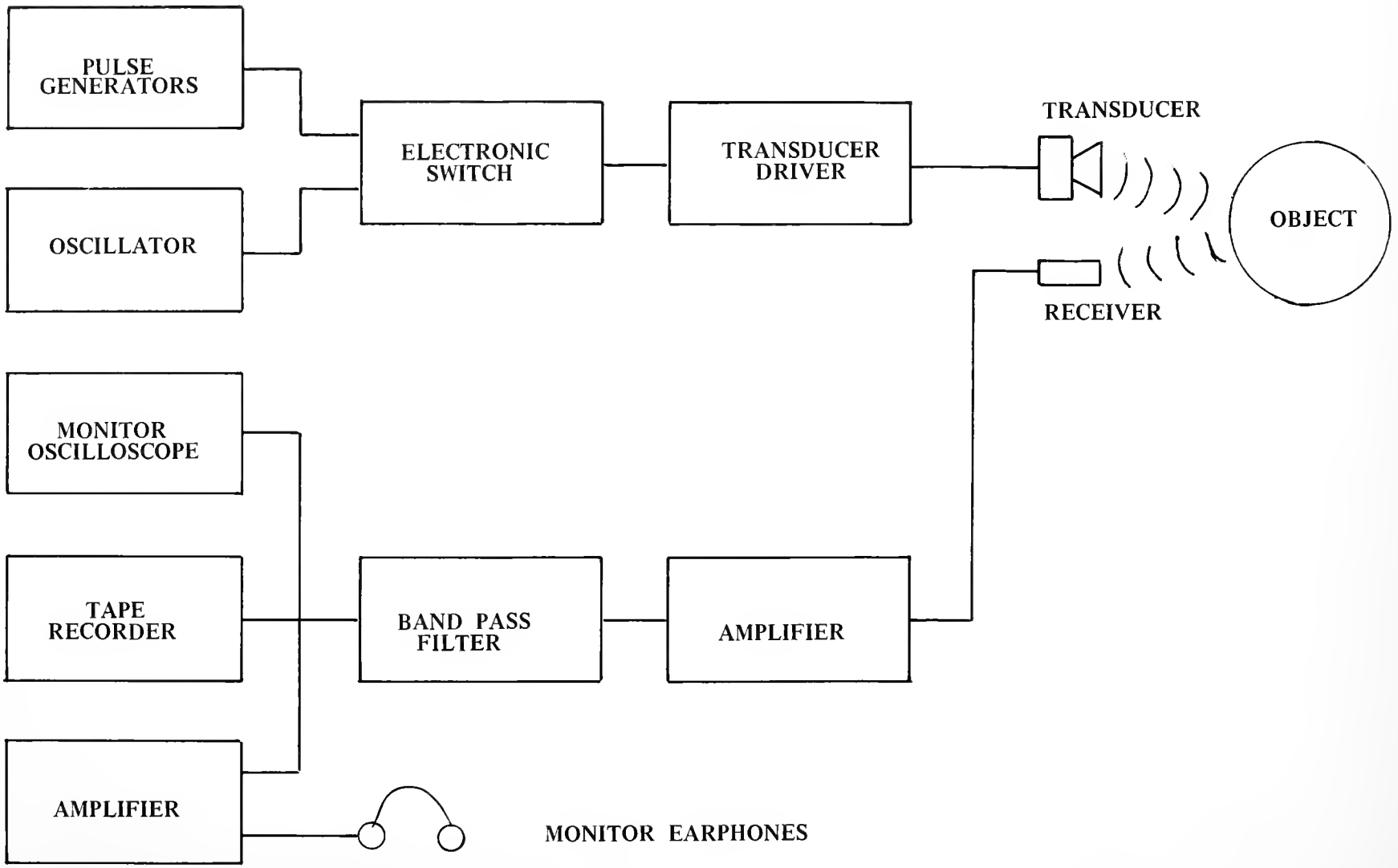


Figure 1. Diagram of the Tape Recorder Set-Up

Table 1

Recording Conditions for Echoes Used in Experiments

Echo Number	Object	Conditions
1	Bush	Bush at 4 ft. Source aimed at bush center line.
2	Bush	Bush at 6 ft. Source aimed at bush center line.
3	Bush	Bush at 8 ft. Source aimed at bush center line.
4	Bush	Bush at 4 ft. Source aimed at left edge of bush.
5	Bush	Bush at 4 ft. Source aimed at right edge of bush.
6	Stool	Stool at 4 ft. Stool perpendicular to source.
7	Stool	Stool at 4 ft. Stool rotated 45 deg.
8	Stool	Stool at 4 ft. Stool rotated 30 deg.
9	Person	Person at 4 ft. Person facing source. Source pointed at person's center line.
10	Person	Person at 4 ft. Person facing 90 deg from source. Source pointed at person's center line.
11	Person	Person at 6 ft. Person facing away from source. Source pointed at person's center line.
12	Person	Person at 4 ft. Person facing source. Source pointed at person's right arm.
13	Waste-paper basket	Basket at 4 ft. Source pointing at basket's center line.
14	WPB	Basket at 6 ft. Source pointing at basket's center line.
15	WPB	Basket at 4 ft. Source pointing at basket's left edge.
16	Wall	Wall at 4 ft. Source pointing perpendicular to wall.
17	Wall	Wall at 4 ft. Source pointing at 30 deg angle with respect to the wall.
18	Wall	Wall at 4 ft. Source pointing at 45 deg angle with respect to the wall.

Before experiment A began, the subjects were handed the following instructions:

Instructions Issued Before Experiment A

> You will hear on the earphones during a trial the echoes recorded from four different objects. The purpose of the experiment today is to see if you can learn to associate the objects and their echoes. The objects are as follows: *(1)* bush; *(2)* stool; *(3)* person; *(4)* wastepaper basket.
>
> You will first be told the object and then will hear its echo repeated several times. This will be done for all objects twice. During this time you may use the pencil and paper provided to make notes concerning the quality or characteristics of the echoes.
>
> After the learning trials the echoes will be presented in a random order. There will be twenty trials. It will be your task to identify the echoes correctly with the associated object. A response to each trial is required.

The subjects were given eight trials at the beginning of the experiment in which they were told the name of the obstacle and subsequently heard its associated echo played approximately fifteen times. Twenty trials followed in which an echo was heard five times during a trial. During the twenty trials the stool echo appeared six times, the bush echo appeared five times, the wastepaper basket echo appeared four times, and the person echo appeared five times. The time between trials was not held constant but varied little from 30 secs. The subjects were not warned before the beginning of a trial.

A slowdown ratio of 64:1 was used for these trials because preliminary work by the author had indicated that this ratio would be an interesting one to investigate. A higher ratio seemed to draw out the echoes excessively and lower ratios did not seem to give as much character to the echoes. Also, a ratio of 64:1 had proven in other work to be an interesting slowdown ratio for listening to bat pulses. It should be pointed out at this time that the only slowdown ratios considered in this thesis are 8:1, 16:1, 32:1, and 64:1. These ratios were considered because these were the slowdown ratios available on the tape recorders used in this work and because lower ratios appeared to compress the echoes so much that the temporal characteristic could not be discriminated.

The results of experiment A are summarized in Table 2.

Table 2

Results of Experiment A

Subject	Number of Incorrect Responses
HSR	3
MJN	1

The combined scores were thus 90 percent correct. These results indicate that there may well be enough information contained in the echoes presented in this test to allow them to be readily identified with the objects they represented. Also, it is important to note that both subjects felt that hearing an echo only one or two times during a trial was enough to identify it.

Experiment B: In experiment A it is not completely clear whether the subjects made their judgments on the basis of information contained in the echoes only, or whether they used extraneous information not related to the echoes. Some extraneous information (artifacts) that might have been present are the noise level of the recording, echoes from the back or side walks, source pulse presence, and intensity differences of the echoes. In order to test for this latter artifact, experiment B was conducted. A single subject (HSR) was given ten trials under the same conditions used in experiment A except for one change. On each trial the stimulus could appear at one of three intensity levels. The middle intensity was the same as the one used in experiment A and the other two were 10 db above and below this level. The instructions below were given to the subject before the experiment began.

Instructions Issued Before Experiment B

> There will be ten trials in which the intensity of the stimulus will vary from trial to trial. The task is the same as before—to associate echo and object. You may make any notes desired throughout the test. A response to each trial is required.

The subject in this experiment correctly identified all ten trials and experienced no difficulty in making the judgments. These results indicate that the subjects were probably not using the artifact of intensity to identify the echoes in experiment A. Further, and more importantly, the intensity level of the echoes given to the subject may not be a critical factor in the recognition of the identity of an object. This would be a most desirable situation in terms of a practical device since the intensity of the echo received from an object will depend greatly on the distance from the source to the object.

Experiment C: While the above results are encouraging, in practice the use of the proposed echo identity scheme will be considerably complicated by the fact that all objects will not be 4 ft away and by the fact that an object may be approached from a variety of angles. In order to investigate whether one might be able to identify an object under varying circumstances, experiment C was performed. Eleven more echoes were recorded under the condition indicated in Table 1. These are echoes number 2, 3, 4, 5, 7, 8, 10, 11, 12, 14, and 15 of that table. Not indicated in the table is the fact that the noise level was 10 db higher during the recording of the echo numbers 3, 5, 6, 7, 8, 14, 15 than it was during the recording of the other echoes. The noise variation was intentional because in practice a person would have to deal with such situations. The eleven new echoes were arranged in a random order and given to the subjects under conditions identical to those used in experiment A. During experiment C the eleven new echoes were given in the first eleven trials and the subject was told the correct answer after each trial. Then the echoes were reordered and given again without reinforcement. The instructions below were issued to the subjects before the experiment began.

Instructions Issued Before Experiment C

> During this test you will first hear as a refresher the four echoes that you are already familiar with. Next there will follow twenty-two trials. These trials will be the echoes recorded from the four objects used previously: bush, stool, person, and wastepaper basket. However, these echoes were recorded under conditions somewhat different than those used before. It is your task to assign an object to each trial. A choice must be made even if it seems arbitrary. After each of the first eleven trials you will be told the correct echo classification. You may make any notes desired throughout the test.

Table 3

Results of Experiment C

Subject	Trials	Number of Incorrect Responses
HSR	1-11	3
MJN	1-11	5
HSR	12-22	4
MJN	12-11	4

Table 4

A Tabulation of the Results of Experiment C

	Bush				Stool		Person			WPB	
	2	3	4	5	7	8	10	11	12	14	15
Bush	S1 M2	S2	S1 M1 S2 M2	S1			S1	S2			
Stool	M1 S2	M1 S1		M1 S2	S1 M1 S2	S1 M1 S2 M2		S1 M1	M1 M2		S2
Person		M2		M2	M2		M1 S2 M2	M2	S1 S2		
Wastepaper Basket										S1 M1 S2 M2	S1 M1 M2
No. of Errors	0	3	0	3	1	0	1	3	2	0	1

Symbols:

S1–HSR's responses on trials 1–11
M1–MJN's responses on trials 1–11
S2–HSR's responses on trials 12–22
M2–MJN's responses on trials 12–22

The combined results give a correct response score of 64 percent for the entire series of trials, and the same score for each of the eleven trial subdivisions. Subject HSR performed slightly better than MJN—68 percent correct compared to 60 percent correct. Random guessing would give results of only 25 percent correct. Table 4 tabulates the classifications made by the subjects for each echo used. From this table it can be seen that the echoes from the stool and wastepaper basket were seldom missed but that the echoes from the bush and person were missed on 50 percent of the trials. The wastepaper basket appears to give the most distinctive echo.

The results of experiment C are, in the author's opinion, the most interesting of the entire thesis. They suggest that the display method proposed may indeed be a useful way to give obstacle identity information to a blind traveler.

Experiment D: This experiment was similar in all respects to experiment C except that all fifteen echoes were used. There were thus thirty trials—the first fifteen with reinforcement and the last fifteen without reinforcement. This experiment was performed one day later than experiment C in order to confirm the previous results obtained. The results of experiment D are summarized in Table 5.

Table 5

Results of Experiment D

Subject	Trials	Number of Incorrect Responses
HSR	1-15	5
MJN	1-15	7
HSR	16-30	6
MJN	16-30	4

The combined scores of the two subjects show a correct response of 63 percent. Table 6 tabulates the classification made by the subjects for each particular echo used in this experiment. It is interesting to note that the reference echoes 1, 6, 9, and 13 were correctly identified whenever they occurred. The person and wastepaper basket echoes appear to be the easiest to identify in the experiment. The bush was frequently identified as a stool.

Experiment D confirms the results obtained in experiment C.

Table 6

A Tabulation of the Results of Experiment D

	Bush			Stool						Person			WPB		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Bush	S1 M1 S2 M2			M2	S1 M2		S2			M1					S2
Stool		S1 M1 S2 M2	S1 M1 S2 M2	S2	M1 S2	S1 M1 S2 M2	S1	S1 M1 S2				S1 M1			S1
Person				S1 M1			M1 M2		S1 M1 S2		S1 M1 S2 M2	S2 M2			
Wastepaper basket								M2					S1 M1 S2 M2	S1 M1 S2 M2	M1 M2
No. of errors	0	4	4	3	2	0	3	1	0	1	0	2	0	0	2

Symbols:

S1—HSR's responses on trials 1—15
M1—MJN's responses on trials 1—15
S2—HSR's responses on trials 16—30
M2—MJN's responses on trials 16—30

Experiment E: An important parameter in the display method being discussed is the slowdown ratio. The experiments to be described below were conducted to investigate the effect of slowdown rate on echo recognition. In experiment E the four echoes used were the same ones used in experiment A. The test conditions were the same as those used in experiment A except that the stimuli were echoes obtained with different slowdown rates. Instructions identical to those used in experiment A were given to the subjects.

Because the echoes used in this experiment were recorded on tape, the different echo slowdown rates were obtained by adjusting the speed of the playback tape recorder. This not only altered the duration of the echoes but also the time between them. Table 7 summarizes these effects. Because in actual use of the display method a person might have a given length of time in which to make an object identification, the time of the stimuli during the trials was kept constant. Hence, the subjects heard twice as many echoes during trials at a ratio of 8:1 as they did at a ratio of 16:1. The results of experiment E are summarized in Table 8.

Table 7

Effects of Tape Playback Speed

Slowdown Ratio	Separation of Echoes in msec	Frequency in kc/sec
64:1	3,200	0.625
32:1	1,600	1.25
16:1	800	2.5
8:1	400	5.0

Table 8

Results of Experiment E

Slowdown Ratio	Subject	Number of Incorrect Responses	Combined Percentage Correct
32:1	HSR	0	80
	MJN	8	
16:1	HSR	3	78
	MJN	6	
8:1	HSR	3	72
	MJN	8	

The results seem to indicate that the tape speed may have little effect on the ability to recognize the echoes within the limits considered. Subject HSR performed significantly better than subject MJN. Ten trials with subject HSR were conducted at each of the slowdown rates 32:1, 16:1, and 8:1 under conditions identical to those used in experiment B—that is, the intensity of the stimuli was varied from trial to trial. The results were essentially the same as those obtained in Table 8 for this subject and indicate that intensity was not being used as an artifact to identify the echoes.

Experiment F: The experiments just described are subject to the same limitations as those in experiments A and B. Namely, the task of the subjects was much simpler than what would be required in the actual use of the display method. In order to consider a more realistic situation, tests of the type described in experiment C were conducted with slowdown rates of 64:1, 32:1, 16:1, and 8:1 in that order. The eleven echoes used in experiment C were used for these tests. At each slowdown ratio eleven trials without reinforcement were conducted. Results of these experiments are summarized in Table 9.

Table 9

Results of Experiment F

Slowdown Ratio	Subject	Number of Incorrect Responses	Combined Percentage Correct
64:1	HSR	3	73
	MJN	3	
32:1	HSR	4	59
	MJN	5	
16:1	HSR	6	36
	MJN	8	
8:1	HSR	6	32
	MJN	9	

The test at the ratio 64:1 was made to confirm previous results and to give a standard of comparison for the following ratios. The results indicate that slowdown ratios of 64:1 and 32:1 may be useful for a practical obstacle identification device. Changing the ratio from 32:1 to 16:1 drastically reduced the subjects' ability to make correct identifications. Ratios below 16:1 may be too low for identification information to be recognized without a lengthy learning period.

Throughout the experiments the subjects were allowed to make any diagrams or notes they desired. The only things they recorded were drawings showing what they thought to be the intensity versus time relation of the four standard echoes used in experiment A. In the trials where other echoes were used, the subjects tried to fit the sound patterns they heard to the patterns they had drawn. The subjects' drawings closely resembled the oscilloscope traces of the echoes, although the subjects were never allowed to see the echoes displayed on an oscilloscope. Considering the nature of the source signal (40 kc/sec; 1 msec), the subjects most probably used only temporal characteristics to make their identifications. This would explain the sharp decline in the results of experiment F between ratios of 32:1 and 16:1. The temporal characteristics that could be heard at 32:1 may have been too closely spaced for accurate recognition when heard at 16:1.

SIGNAL DESIGN

As mentioned in the previous section, the types of signals produced by the sound source transducer may influence greatly the ability of a person to identify echoes using the display method discussed. In this section some very preliminary results concerning signal selection are discussed.

In the consideration of the pulsed sinusoid signals used in this experiment, there are two variables of interest—the frequency of the pulse and the duration of the pulse. In order to investigate the effects of these two variables, echoes from a variety of objects were recorded using different source signals. A tabulation of the objects and the signals considered is given in Table 10.

These frequencies were chosen because they include the frequency range most often used in ultrasonic devices that have been constructed in the past. The lower choice of 40 kc/sec keeps the source signal well above the audible range and has a relatively short wavelength (0.33 in.). Because the absorption coefficient of sound increases as the square of the frequency, at very high frequencies attenuation may become a problem.

The durations were chosen because they represent signals whose length in air varies from slightly shorter than the depth of most of the test objects (0.5 msec; 6 in.) to a signal slightly longer than the typical test object depth (2 msec; 2 ft).

Table 10

Tabulation of Objects and Signals Used During Signal Design Experiments

Objects	Signals	
	Frequency (kc/sec)	Duration (msec)
1-in. diameter wooden rod		
3-in. diameter metal pipe	40	5
4-in. diameter plastic ball	40	1
10-in. diameter plastic ball	40	2
6-in. high stepup	60	1
Stool	80	0.5
Wastepaper basket	80	1
Person facing sound source	80	2
Glass plate		
Wall perpendicular to source		
Wall at 30 degrees		
Wall at 45 degrees		

On the recordings made in this series both the source pulse and the echo were recorded. At a slowdown ratio of 64:1, two subjects listened to the recordings made for each signal and each object. The procedure was to play five source and echo pairs recorded using a particular signal and object. After hearing this recording the subjects were asked to make a subjective judgment as to whether the source and echo sounded sufficiently different to them so that they could distinguish between the two at least 90 percent of the time in a test of the type performed in experiment B (variable intensity trials). Thus, intensity was not to be considered a factor. The objects were placed 4 ft from the sound source during recording so that the delay between a source pulse and an echo was approximately 500 msec in all cases. A source pulse, followed by an echo, occurred every 3.2 sec. The above question

was asked concerning each echo-source pair recorded using a particular signal. Then the same procedure was used with the other types of signals.

It was assumed that if the echo from an object sounded different from the source pulse there might then be a reasonable chance of identifying the object by its echo; but if the source and echo pulses were indistinguishable during these tests then there was relatively little chance of identifying the object by its echo. These assumptions have obvious shortcomings, but it was felt that this method would reveal any gross differences in the identification abilities of the signals.

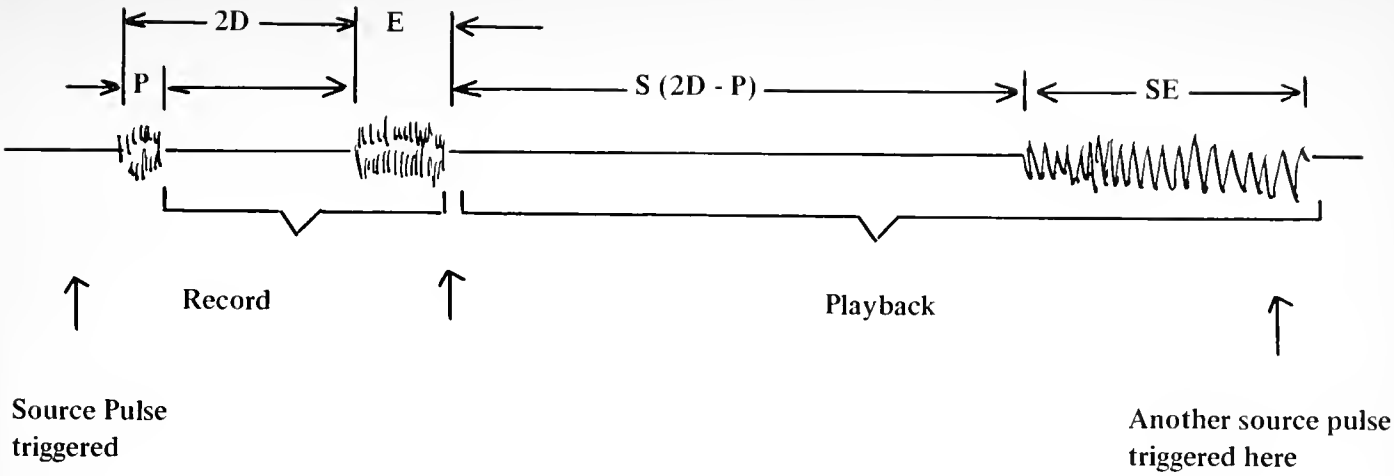
The fewest number of objects indicated by the subjects as significantly different from the source during trials using a particular signal was four (this is the average of the two subjects' scores); the maximum number of objects indicated was six. These results imply that frequency and duration may not be especially significant parameters within the limits considered.

For anyone interested in echolocation, a swept frequency signal is one that comes immediately to mind because of the remarkable success that some species of bats have achieved using this type of signal. The merits of this type of signal are discussed in reference 28. Echoes were recorded from the last nine objects in Table 10 using a source signal swept from 100 kc/sec to 50 kc/sec in 1 msec. This type of signal is frequently used by the Myotis bat. The echoes were evaluated in the same manner used for the pulsed sinusoid signals. The results were quite interesting. One subject made eight positive responses and the other subject indicated nine. Subject HSR, who had participated in the experiments described in the previous section, felt that this type of signal gave a considerably more distinctive quality to the echoes from different objects than did the 40 kc/sec-1 msec pulse. The subject expressed confidence in her ability to identify correctly all nine echoes in experiments of the type conducted in the previous section. However, further tests were not conducted using this type of signal.

DISTANCE DISPLAY EXPERIMENTS

Having indicated previously that a time expansion display may provide considerable object identity information, it is important to consider whether such a display is also capable of providing the required distance information. In this section a display scheme is discussed that will retain most of the echo identity information and also provide distance information.

Suppose that the energy source of a mobility aid emits a burst of sound energy P msec long. Because sound travels about 1,130 fps in air at room temperature (25), it will travel 1.13 ft/msec. For the purposes of the calculation below let us assume that it travels 1 ft/msec. Because the distances and times considered are small the error will not be appreciable. An object D feet from the energy source will then return an echo $2D$ msec after the source pulse is emitted (see Figure 2). Suppose the echo is recorded for a time E. The mobility device will begin recording the returning echoes as soon as the source pulse has



D = distance from source to nearest object in feet

P = length of source pulse in msec

E = echo recording time in msec

S = slowdown or stretch factor

R = repetition time = (2D + E) + S (2D + E - P) msec

Figure 2. A Possible Distance Display Method

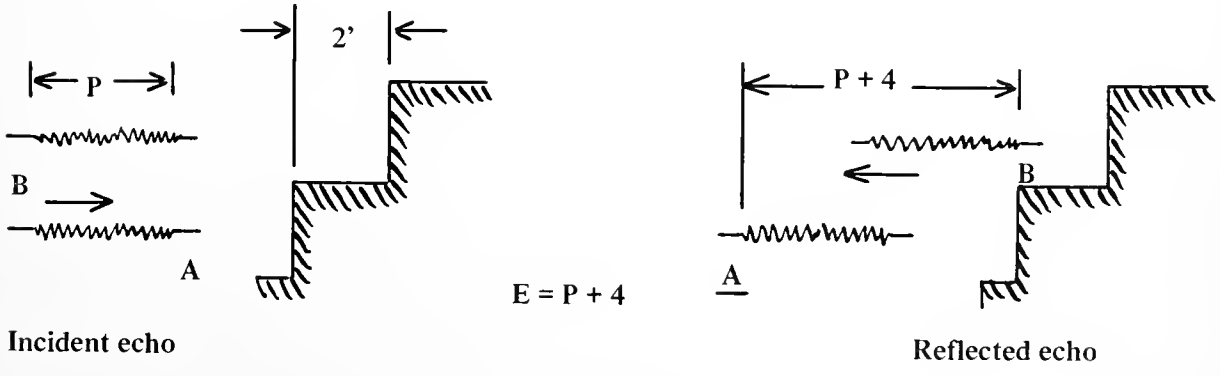


Figure 3. An Illustration of the Specification of E

been emitted. By using relatively short pulses, it may be possible to use the same transducer to emit the energy pulse and to receive the echoes. After an echo has been recorded for a time E, the device plays the recording to the listener using a time expansion ratio or stretch S. Immediately after the recording has been played back another source pulse is triggered and the above cycle is repeated. The time between echo sounds depends on D and the repetition rate therefore indicates the distance D.

At first glance the distance display scheme discussed here might be thought to give superfluous information. If it proves to be true that a person is able to identify objects correctly from their characteristic echoes, then he might also be able to determine the distance to the object from the echo intensity. For example, if a person hearing the echo from a tree could correctly identify the object as a tree, then the intensity of the returning echo would tell him the distance to the tree. While this may be possible in some situations, the method has obvious difficulties. A rough brick wall may give a much weaker echo than a smooth concrete wall at the same distance. It therefore seems advisable to use different dimensions to display the object identity information and the object distance information.

From Figure 2 it can be seen that the time between echo sounds (R) will be

$$R = (2D + E) + S(2D + E - P) \text{ msec}$$

This equation is not correct dimensionally, but because we assumed that sound travels 1 ft/msec we can use distance and time interchangeably.

To evaluate this scheme it is necessary to specify values for the variables. First, let us consider E. This value should probably be large enough so that the entire echo reflected from an object is recorded. Thus E depends on the object size and the source pulse length. Because many objects that it will be desirable to identify will have a depth of 1 to 3 ft, let us assume an average object depth of 2 ft. From Figure 3 it can be seen that there will be $P + 4$ msec from the time the first indication of an echo is received from the front of the object (point A) until the last indication of an echo is received from the rear of the object (point B). Therefore, $E = P + 4$, and the repetition time becomes

$$R = 2D + P + 4 + S(2D + P + 4 - P)$$

$$= (S + 1)(2D + 4) + P$$

Considering the results arrived at previously, we are most likely to be interested in slowdown ratios of 8, 16, 32, and 64. From results obtained with guidance devices in the past, the range of greatest interest appears to be 0 to 15 ft, and for purposes of these calculations let us assume P is 1 msec. The values in Table 11 may be calculated using the above assumptions.

Table 11

Echo Separation Times for Various Slowdown Ratios and Distances

D/S	1	2	3	4	5	10	15	Diff/Ft
8	55	73	91	109	127	217	307	18
16	103	137	171	205	239	409	573	34
32	199	265	331	397	463	793	1,123	66
64	391	521	651	781	911	1,561	2,211	130

All times in msec

The last column in the table indicates the change in repetition time R when the obstacle distance D changes by 1 ft. This change is independent of D and P; it equals 2 $(S + 1)$. It should be noted that because the last column is independent of D, the difference per foot as a percent of repetition time decreases as D increases. For example, the percent change in repetition time from 1 to 2 ft is 33 percent, while the change from 10 to 11 ft is about 8 percent. Thus, changes in distance at close ranges would be more perceptible with this type of display than would changes at large ranges (2). Because a blind traveler will most likely be interested in accurate obstacle location at close ranges, this situation will probably not be a disadvantage.

A blind person in a familiar and uncongested environment may be assumed to walk at a pace of about two steps per sec (11). If he moves forward 2 ft with each step, his travel rate is then 2 ft per 500 msec. Suppose we consider a worse case situation in which an obstacle (for example, a person) intersects the blind person's path at a right angle. In such a situation the obstacle would appear immediately somewhere within the device's range. The device should give adequate warning to avoid collisions with such suddenly-appearing obstructions. If we consider a slowdown ratio of 64:1 and that the new obstacle appears at point A in Figure 2 (just after the playback phase begins), it can be easily calculated that the delay until the new obstacle is indicated by the device will be approximately 2.8 sec. This will clearly not be enough warning to avoid a collision, because during this time the traveler could have moved about 11 ft. The delay in warning at a slowdown rate of 32 in the above circumstance might be as long as 1.4 secs. In this time a traveler will move 5.6 ft and still collide with the obstacle. Therefore, with the distance scheme proposed in this section a slowdown ratio less than 32:1 is probably required. However, to be consistent with the results in previous sections of this thesis, the experiments performed below include results using a slowdown ratio of 32:1.

C. M. Witcher (6) suggests that the area before a blind traveler may be divided into three zones: an outer awareness region, a middle "attention" region within which objects may require a decision to change course, and an inner "avoidance" region where action is imperative. At a normal walking rate the appropriate widths may be estimated at about 5 ft each. With this suggestion in mind the following experiments were performed. Subjects listened to the pulse repetition rates associated with distances of 5, 10, and 15 ft and a slowdown ratio of 16:1. The pulses that the subjects heard were 2.5 kc/sec and 16 msec duration. Such a pulse might be that of the echo from a wall when a source pulse of 40 kc and 1 msec duration is used and the recorded echo is expanded 16 times. The subjects were first told a distance and then allowed to hear the pulse repetition associated with that distance. The distances were presented in the order 5, 10, and 15 ft, and this sequence was repeated twice. The subjects then were given a series of twenty trials. Each trial consisted of listening to one of the three pulse repetition rates selected at random. On each trial the subject was required to indicate on paper the distance associated with the repetition rate he had just heard. The duration of the stimulus that the subjects heard on each trial was varied randomly among 2, 3, and 4 secs. It was felt that if the stimulus duration had been held constant the subjects might have simply counted the number of pulses they heard on each trial. The intensity of the pulses was kept constant throughout the experiment. A tape recording was made of the above trials. This recording was speeded up by a factor of two to simulate an expansion ratio of 8:1 and slowed down by a factor of two to simulate an expansion ratio of 32:1. This procedure had the disadvantage of changing the stimulus duration times for each slowdown ratio but kept the number of pulses in a particular trial constant. For instance, if a subject heard 5 pulses in 2 secs on trial 6 when the slowdown ratio was 16:1, he had heard 5 pulses in 1 sec on trial 6 when the slowdown ratio was 8:1. Three subjects with normal hearing were used and the results of the subjects have been combined. The results of this experiment are shown in Table 12.

Table 12

Results of Tests Investigating the Ability to Recognize the Display of 5, 10, and 15 Feet

S	Percent Trials Correct
8	90
16	100
32	93

All subjects felt that the categorization judgments were easy to make. All errors were in adjacent categories. Although the learning period was very short, the subjects performed rather well. The author, in a later test using himself as a subject, found no difficulty in completing sixty consecutive correct trials at a slowdown ratio of 16:1. These experiments indicate that if it proves desirable to divide the forward area into zones as suggested by Witcher (and as the Russell device does), then the distance display scheme described here may be of interest.

For objects that are closer to the traveler than 5 ft, a more accurate indication of their presence than that given by the above scheme may be desirable. With this in mind, experiments simulating distances of 1, 3, and 5 ft as given in Table 11 for a slowdown ratio of 16:1 were conducted. The conditions of these experiments were essentially the same as those in the previous experiment except that the trial stimulus durations were varied randomly among 1, 1, and 3 secs. Results of these experiments are presented in Table 13.

Table 13

Results of Tests Investigating the Ability to Recognize the Display of 1, 3, and 5 Feet

S	Percent Trials Correct
8	93
16	95
32	95

Again the subjects found the categorizations were easy to make and all errors were in adjacent categories. The successful results of this experiment indicate that it might be relatively easy for the distance scheme described here to indicate object distances at close range with an accuracy of ± 1 ft.

In a following experiment distances of 1, 2, 3, 4, and 5 ft were simulated. Experimental conditions were essentially the same as for the experiments described in the preceding experiment. The results of these experiments are shown in Table 14.

The subjects in this experiment felt that the categorizations were difficult to make with a feeling of confidence. Approximately 15 percent of the trials were missed by more than one category. Thus it seems that it will be rather difficult to locate an object at close range to an accuracy of ± 0.5 ft using the proposed distance display.

Table 14

Results of Tests Investigating the Ability to Recognize the Display of 1, 2, 3, 4, and 5 Feet

S	Percent Trials Correct
16	65
32	60

The difficulty occurring in this last test was probably due to a combination of two factors. First, the number of categories had been increased (19). Second, the difference limen between categories had been decreased (2). However, as in the previous distance experiments, the slowdown ratio seems to be relatively unimportant within the limits considered.

COMPUTER SIMULATION

There is another type of distance display that may be of interest in some situations. In this case the device records all echoes received within a specified length of time (for example, 32 msec—corresponding to a range of approximately 16 ft) and replays the entire recording. With such a system some type of marker is necessary to indicate the time of the source pulse with respect to the received echoes. Obstacle distances can be obtained by observing the time delay between the source marker and the object echoes.

As pointed out by Kay (15), for a guidance device of the type discussed in this thesis, navigation may be the most important consideration and obstacle detection may be of secondary importance. A display of the type just described could be used to detect multiple obstacles and might be valuable for navigational purposes. The range could be made variable so that landmarks at a considerable distance might be detected. A cane could be used with the device to detect ground obstacles.

At the beginning of this thesis project it was hoped that the evaluation of the display methods discussed could be made in a real-time, real-space situation. In an effort to do this, the TXO computer was used to do information processing required in the proposed device. The computer was programmed to trigger a hand-held ultrasonic source that emitted a 1 msec pulse of 40 kc sine wave. Samples of the emitted pulse and all echoes returning within a period of 32 msec were stored in the computer. After recording had stopped, the samples were read out of the computer at a slowdown ratio of 16:1. The resulting signal was transmitted over a loudspeaker to the person holding the sound source. Although no quantitative results were obtained in this experiment, range information was readily available from the loudspeaker and easy to interpret. The effect was as if the speed of sound had been

slowed down 16 times (about 70 ft/sec). Despite this interesting situation the computer sampling rate was not sufficient to give an accurate reproduction of the echoes. Because the major purpose of this thesis was to investigate the possible existence of echo identity information, further experiments using the TXO were not conducted.

CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

The purpose of this thesis has been to investigate the possibility of using the time expansion of ultrasonic echoes as a means of facilitating auditory identification of obstacles. The advantages of ultrasound as an energy source and the human auditory system as a sensory input were first discussed. Then several experiments designed to explore the display scheme proposed were conducted. As a result of the work the following conclusions are drawn:

1. The time expansion of ultrasonic signals given to the auditory system appears to be a useful method of giving a blind traveler information about the identity of obstacles in his environment.

2. The echo intensities heard by a person are not likely to be a critical factor in obstacle identification. In actual use intensity may, in fact, provide additional information for identification purposes.

3. Slowdown rates of more than 32:1 appear to be practical rates for obstacle identification purposes. Rates smaller than 16:1 may require considerable learning before they can be used successfully. The higher ratios could well prove useful during this training period.

4. For sound source signals consisting of sine wave bursts, the frequency and duration are apparently not critical design parameters between frequencies of 40 kc/sec to 80 kc/sec and durations of 0.5 msec to 2 msec.

5. By using the distance display method proposed, ranges of 5, 10, and 15 ft and 1, 3, and 5 ft can easily be displayed while retaining all information necessary to identify the nearest obstacle.

6. A digital computer was used between the actual ultrasonic receiver and the acoustic display to simulate in real-time a proposed information processing method involving slow readout of the transmitted pulses and the resulting echoes at a repetition rate of about 2/sec. The apparent time difference between the transmitted pulse and the echo was approximately 30 msec/ft of object distance, which made object distance relatively easy to judge.

In considering conclusion number 1, several factors must be remembered. The subjects used were highly motivated, quite intelligent, and had very good hearing. All echoes were recorded in the anechoic chamber where ambient noise was at a minimum. The subjects were comfortably seated in a soundproof room during the echo

identity experiments. On the other hand, no intensity, environmental, binaural, or scanning information was available to the subjects. The sound source signal was probably not optimum and the subjects had very little training.

These latter limitations suggest several possibilities for future investigations:

1. The important aspect of signal design should be further considered. Some signals that it might be interesting to investigate are the following: a swept frequency signal (bat pulse), a click, a very short sinusoidal pulse, and a very long sinusoidal pulse.

2. The improvement that binaural hearing might offer could be investigated by making two-channel recordings from microphones spaced closely together. The microphone spacing could be adjusted so that the time expanded echoes would retain the interaural time differences occurring with normal hearing.

3. The results concerning echo identification obtained in this experiment could be made more quantitative.

4. Because all echoes used in these tests were made with fixed targets, it might be interesting to investigate how the proposed display method would perform in identifying moving targets and in dynamic situations.

5. Because the purpose of the display method discussed in this thesis is to recognize objects by listening to their echoes, it is important to investigate what characteristics of an echo contain the identity information.

6. The possibilities of using this display method to recognize multiple objects should be studied. Binaural hearing would probably be very useful in this situation.

7. Because of the current inability of ultrasonic devices to detect step-downs, the device proposed in this thesis would probably have to be used with a cane. The possibility of coordinating the use of a cane and an ultrasonic device should be considered.

8. Some method should be found for an ultrasonic guidance device to detect a step-down.

9. There has never been, in the author's opinion, a thorough and rigorous investigation of the information that a mobility aid device should provide for a blind person. Such a study is necessary if useful guidance devices are to be constructed.

10. Most of these suggestions could be effectively investigated if the device proposed in this thesis was constructed and used in real-time, real-space experiments. If the device can be instrumented relatively simply, its construction is certainly the next step that should be taken.

SUMMARY

A useful mobility aid device for the blind should provide at least three types of information. It should indicate the presence of obstacles in the traveler's path, locate these obstacles, and identify them. Many mobility aid devices constructed in the past, while detecting and locating obstacles, have failed to provide sufficient identity information or have provided it at a very slow rate. Experiments were performed to investigate the possibility that persons may be able to obtain object identity information by listening to the time expansion of the ultrasonic echoes produced by a sound source.

The echoes from four objects using a 40 kc/sec ultrasonic pulse of 1 msec duration were recorded under various conditions. Using an expansion ratio of 64:1, subjects were played the echoes in a random order and asked to identify the object producing the echo. The results of this exploratory experiment indicate that the proposed display method provides considerable object identity information to the listener. Further experiments suggest that expansion factors of 64 and 32 produce equally good results, while factors of 16 and 8 may require a more lengthy training period than used in these experiments.

The results suggest that the proposed display method is a promising avenue for future research. Several suggestions are included.

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OCULAR MANIFESTATIONS OF THE 1964-65 RUBELLA EPIDEMIC*

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The New Haven area and surrounding communities were (immunologically) susceptible hosts to the 1964-65 epidemic of rubella, the largest of its kind in the United States in the last twenty years. More than 40,000 cases were reported in a population of 3.5 million in the state of Connecticut (1).

The postrubella syndrome has been described previously as maternal German measles in the first trimester of pregnancy with the subsequent development in the newborn of congenital heart defects, hearing loss, prematurity, mental retardation, and cataracts and other ocular abnormalities (2). This clinical study utilized the information obtained from the new techniques of viral cultures and serologic testing for rubella in the newborn as *prima facie* evidence of the postrubella syndrome. With these criteria for diagnosis, the syndrome was reexamined with special emphasis on the opthalmologic findings with and without other associated manifestations of rubella.

METHODS

All infants born at the Yale-New Haven Hospital and at neighboring hospitals who were suspected of having the postrubella syndrome, either by history of maternal exposure during pregnancy or by suggestive clinical stigmas of the postrubella syndrome, were referred to the Ophthalmology Service of the Yale-New Haven Medical Center for evaluation. One hundred five infants were studied.

VIRAL CULTURES

Viral cultures and serologic studies were available at the Viral Diagnostic Laboratory of this hospital. Throat cultures were obtained from every infant in whom the syndrome was suspected during the first week of life or when the child was initially referred to this hospital. Urine, stool, and conjunctival cultures were obtained from some infants. Patients undergoing ocular surgery had cultures of the lens and/or aqueous humour when this material was available. Culture material was immediately immersed in Hanks' solution and sent to the Viral Diagnostic Laboratories. The indirect interference technique of rubella isolation as described by Parkman was employed, utilizing African green monkey

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kidney tissue cultures (3). The specimens were considered positive if they interfered with the known cytopathic effect of echo virus type 11.

NEUTRALIZING ANTIBODY TECHNIQUE

Serologic evidence for a virus infection was determined in the Viral Diagnostic Laboratories according to the method described by Parkman (4). The blood from mother and child at birth and at intervals up to fourteen months of age was obtained and the sera were measured according to their capacity to block the interference phenomena of known rubella virus. The sera from the patients were innoculated into known rubella virus cultures. The cultures were then challenged with echo type 11 virus. If there were no interference effects, the sera were considered to have antibodies to the virus. The sera were diluted to the greatest dilution that would destroy the interference phenomena. A dilution of 0.25 or greater was considered significant from both mother and child. Antibody titers were considered significant in the newborn only if they persisted after the first month.

Every patient had a complete physical examination performed by the pediatric staff of this hospital. In addition to ocular examinations, all patients had cardiologic, audiologic, and developmental consultations and specialized studies where indicated. All children with positive viral cultures or neutralizing antibodies and most infants who were ultimately not considered to have the postrubella syndrome had complete ocular examinations including biomicroscopy and indirect ophthalmoscopy. In addition, those children with positive laboratory confirmation of the postrubella syndrome had measurements of corneal diameters, ocular tension, outflow facility, and gonioscopy when indicated.

The patients were subdivided into two classes:

1. Negative cultures and negative antibody titers.

2. Positive cultures and/or significant antibody levels.

Included in the negative group were those patients who had evidence of maternal rubella after the first trimester as documented by a physician and therefore had evidence of a virus infection but no possibility of embryopathic effect.

Patients with positive cultures and/or neutralizing antibodies were further classified according to the presence or absence of ocular abnormalities. The frequency of each specific ocular lesion was determined. Systemic manifestations of the postrubella syndrome in each group were analyzed. Each category was tabulated according to whether a positive ocular culture for the rubella virus was obtained.

RESULTS

In all, 105 suspect patients were referred to the Ophthalmology Service for suspicion of the postrubella syndrome. This represents the total study analyzed in Table 1. Of this group, 56 patients (53 percent) had negative viral cultures or insignificant

Table 1

Classification of Patients Suspected of Postrubella Syndrome

Class	Description	No.	Percent
1	Patients with negative viral cultures and insignificant neutralizing antibody titer levels	56	53
2	Patients with either positive viral cultures or significant neutralizing antibody titers	49	47
2a	Patients of Class 2 with abnormal eye findings	24	23
2b	Patients of Class 2 with no abnormal eye findings	25	24

antibody titers (Class 1). This group was considered not to have the postrubella syndrome. The only situation in which a positive culture or significant neutralizing antibody titer was not considered as *prima facie* evidence of potential damaging rubella infection was in the instance of a documented maternal infection of German measles after the sixteenth week of gestation. In this instance, the child would not have the embryopathic effects, as has been shown by Mann and others (5), but would have a serologic response and viremia.

All other patients in Class 1 had negative cultures and absent antibody neutralizing titers but had one or more stigmas of the postrubella syndrome which aroused the suspicion of the referring physician. No patient in this group had any ocular abnormalities.

There were 49 patients (47 percent) who had positive virus cultures or significant neutralizing antibody titers. These were designated Class 2. Many of these patients had no history of maternal rubella and some had only minimal clinical evidence of the disease. None of the patients in Class 2 had a documented history of maternal rubella after the first trimester of pregnancy.

The patients with the postrubella syndrome were subdivided into patients with and without ocular lesions (Table 2). Twenty-four patients (23 percent) of the total examined (or 49 percent of those having the postrubella syndrome by the strict criteria already outlined) had ocular abnormalities (Class 2a). Table 3 lists the specific ocular abnormalities found in 24 patients (48 eyes) in Class 2a. Although 63 percent of the 48 eyes had cataractous change, 19 of 24 patients in this group (79 percent of the patients) had either binocular or monocular cataracts. The cataracts were of the zonular type with

Table 2

Patients with Postrubella Syndrome as Defined by Positive Culture or Positive Antibody Titer

Description	No.	Percent
With ocular abnormalities (Class 2a)	24	49
Without ocular abnormalities (Class 2b)	25	51

varying degrees of peripheral clarity, ranging from minimal to marked density. The operative experience with these cataracts will be described in a subsequent communication. One interesting observation in this regard was that the central nucleus was noted to be firm and coherent during cataract extraction.

Pigmentary changes of the retina were seen in 38 percent of the eyes in which the fundus could be visualized. The degree of retinopathy was variable and similar to that previously described by Francois (6). Minimal pigment dispersion was seen in some, while others demonstrated significant pigmentary clumping and atrophy involving the posterior pole and the periphery to varying degrees.

The incidence of 38 percent of eyes having retinal changes deserves special note. This represents a significant proportion of the involved eyes. Further analysis of the data suggests that, if all fundi which were obscured by cataracts or corneal opacities could have been examined, the incidence of retinopathy would be higher. Of the eight patients with monocular cataracts, seven had retinopathy in the fellow eye with clear media. In the ten patients with binocular cataracts in whom removal of the cataracts provided a clear view of the fundus, four had bilateral retinal pigmentary change. It therefore can be assumed that many of the patients in whom the fundi could not be visualized also may have had chorioretinal changes. An estimated incidence of retinopathy might be as high as 45 percent of those eyes with ocular abnormalities in the postrubella syndrome.

Nystagmus was present in approximately one third of the patients with ocular abnormalities. It was of the searching character, as has been previously described by Francois (6). Nystagmus was observed only when there was binocular impairment of vision as a result of cataracts. It was absent at birth and noted for the first time during monthly examinations at about three months of age. Following cataract extraction, the nystagmus was noted to improve in the operated eye. Improvement in the nystagmus followed the application of corrective lenses and was not completely eliminated in any of the patients at the time of this report. (Maximum observation was 13 months postoperatively.)

Most patients with ocular disease had iris involvement. This varied from poorly dilating pupils, even in patients with full-term weights, to irregular transillumination of the iris, which was seen in 16 eyes. One patient had a partial aniridia. Another patient had an inferior segmental iris coloboma. The patient with unilateral aniridia had a unilateral central corneal opacity measuring 2.5 mm in diameter in the same eye. This patient showed normal corneal diameters, anterior chambers and ocular tensions. The corneal opacity involved the deep stroma and was without any folds or breaks in Descemet's membrane. It was present at birth and has remained unchanged at the time of this report at the age of fifteen months.

Two other patients were noted to have bilateral corneal haze. These patients had glaucoma as determined by enlarged corneal diameters, elevated ocular tensions, and reduced facility of aqueous outflow. One of these patients, whose chamber angles were visualized and found to be normal in appearance, underwent bilateral goniotomies with subsequent normalization of intraocular pressure. The other patient presented with dense corneal opacities and thinning of the cornea which resulted in perforation and loss of one eye. The fellow eye responded poorly to cyclodiathermy.

Routine retinoscopy was not performed on the patients in this study. Therefore, evidence for microophthalmia could not be obtained. Patients were considered to have microcorneas, however, if they were full term and had corneal measurements in vertical and horizontal meridians of less than 9.0 mm. By these criteria 25 percent of the full-term children had microcornea.

Unilateral nasolacrimal duct stenosis was diagnosed by probing, under anesthesia, with the tactile sensation of a resistant membrane at the nasal end of the duct. This was observed in two patients, both of whom showed improvement after a single probing.

Patients with ocular abnormalities of the postrubella syndrome were studied to determine the incidence of the involvement of other organ systems. Of the patients with ocular abnormalities, 96 percent had cardiopathy. This high correlation of eye and heart lesions, rather than the classical description of eye and hearing defect, has been reported by Auw-Yang and others in the European literature (7). All patients who had a heart murmur were examined by a senior pediatric cardiologist and had catheterization, EKGs and angiograms when indicated.

Table 3 lists the specific cardiac defects. Many of the patients had multiple lesions, which are listed separately. A high frequency of patent ductus arteriosis was observed. Of special interest is the high incidence of peripheral pulmonary stenosis which was documented in each case by catheterization studies.

Table 3

Specific Eye Findings in Class 1a (48 Eyes)

Eye Findings		No. Eyes	Percent
Cataracts		30	63
Monocular	8		
Binocular	11		
Retinopathy		18	38
Nystagmus		18	38
Iris hypoplasia*		16	33
Microcornea		12	25
Glaucoma		4	8
Corneal haze		2	4
Lacrimal duct obstruction		2	4
Corneal opacity		1	2
Coloboma of the iris		1	2

**Defined as areas of transillumination or absence of iris tissue.*

The common findings in the postrubella syndrome of hearing loss (17 of 33 children evaluated by Hardy and associates [8]) and mental retardation concurrent with ocular disease were again seen in this epidemic. An unusual associated finding in this series was the relatively high frequency (13 percent) of thrombocytopenic purpura. In addition, x-ray changes of the long bones, biliary atresia, kidney abnormalities, neurologic defects, and pyloric stenosis were seen and are tabulated according to frequency in Table 4.

In Class 2b, 25 patients (51 percent) of the positive rubella group had normal ocular examinations. Table 5 lists the findings in patients with postrubella syndrome who did not have ocular disease. In contrast to the 96 percent association with congenital heart defects in the group with ocular involvement, only 56 percent of Class 2b had cardiopathy. Patent ductus arteriosis was again the most common cardiac lesion. Mental retardation and hearing loss were significantly less frequent in patients not having ocular disease. The incidence of thrombocytopenic purpura (25 percent) was unusually high in this group, as well as in the patients with ocular involvement. Other findings seen without eye lesions included pancreatic insufficiency, pancytopenia, esophageal atresia and cleft palate.

Every child in the series had initial throat cultures and neutralizing antibody titers for the rubella virus from mother and infant. Follow-up serology was obtained in all but a few cases. By definition all patients with postrubella syndrome (Classes 2a and 2b) had either positive viral cultures or significant antibody titers, though not necessarily both. As shown in Table 6, of the patients in Class 2a, 71 percent had a positive viral culture and 83 percent had significant antibody titers. Those patients without ocular disease with the postrubella syndrome (Class 2b) demonstrated 56 percent positive cultures and 68 percent significant antibody levels.

Table 4

Associated Systemic Findings of the Postrubella Syndrome in Patients with Ocular Disease (24 cases)

Systemic Findings	No.	Percent
Heart	23	96
Patent ductus arteriosis	16	
Peripheral pulmonary stenosis	6	
Ventricular septal defect	4	
Pulmonary artery stenosis	2	
Atrial septal defect	2	
Wolf-Parkinson-White syndrome	1	
Transposition	1	
Endocardial cushion defect	1	
Prematurity (wt., 5.5 lb)	10	42
Hearing loss	12	50
Mental retardation	9	38
Thrombocytopenic purpura	3	13
X-ray evidence of bony changes	3	13
Pancytopenia	1	4
Porencephaly	1	4
Pyloric stenosis	1	4
Bilary atresia	1	4
Kidney deformity	1	4

The most frequent source of positive cultures came from the throat in all groups. In addition to routine cultures of the throat, stool and urine, conjunctival cultures were done on 25 patients in the series (Table 7). In patients with clinical features but no laboratory evidence of postrubella syndrome (Class 1), seven cultures were attempted and none were positive. In postrubella patients with ocular disease (Class 2a), 13 cultures were attempted and five were positive, or 39 percent of those attempted. In postrubella patients without ocular disease (Class 2b), five cultures were attempted and none were positive.

Table 8 lists the patients with positive conjunctival cultures and shows the degree of ocular involvement, which, in most cases, was widespread, but in one case involved only nasolacrimal duct obstruction.

Table 5

Associated Systemic Findings of the Postrubella Syndrome in Patients Without Ocular Disease (25 cases)

Systemic Findings	No.	Percent
Heart	14	56
Patent ductus arteriosis	10	
Atrial septal defect	2	
Ventricular septal defect	2	
Tetralogy of Fallot	2	
Coarctation of aorta	2	
Peripheral pulmonary stenosis	1	
Prematurity (wt., 5.5 lb)	10	40
Thrombocytopenic purpura	5	20
Mental retardation	2	8
Hearing loss	2	8
Pancreatic insufficiency	2	8
Pancytopenia	1	4
Esophageal atresia	1	4
Cleft palate	1	4

Table 6

Virus Culture and Neutralizing Antibody Studies

Class	Positive Culture of Throat, Urine, or Stool		Significant Antibody Level (1:4)	
	No.	%	No.	%
Class 1 (56 patients)	1	2	2	4
Class 2a (24 patients)	17	71	20	83
Class 2b (25 patients)	14	56	17	68

Table 7

Results of Conjunctival Cultures

Class	No. Patients	No. Cultures Attempted	No. Cultures Positive	Percent Positive
1	56	7	0	0
2a	24	13	5	39
2b	25	5	0	0

Table 8

Eye Findings in Patients with Positive Conjunctival Cultures

Patient	Age at Time of Positive Culture	Cataract RE	Cataract LE	Retinopathy RE	Retinopathy LE	Nystagmus	Iris	Microcornea	Lacrimal Duct Obstruction
S.C.	At birth	+	+	+	+	+			
W.McD.	1 wk	+	+	+	+	+	+	+	
J.D.	2 mo	+	+	+	+	+			
A.V.	At birth	+	+	?	?	+	+		
S.G.	At birth						+		+

DISCUSSION

This study represents an analysis of the 1964-65 epidemic of rubella in the New Haven community. The selection of patients for this series was determined by the clinical suspicion of a gestational rubella infection. The diagnosis was established by the serologic and/or virologic evidence of the disease. The strict criteria of positive culture or significant

serologic response to the virus were used as *prima facie* evidence of the postrubella syndrome. With this requirement for diagnosis, the embryologic effects of the rubella gestational infection and resulting congenital abnormalities were reexamined.

Those patients who had ocular disease had a higher incidence of the commonly associated systemic abnormalities, particularly cardiac lesions, hearing loss, and mental retardation.

An explanation of the increased incidence of systemic findings in patients with ocular disease may be found in one or a combination of a number of factors. The associated findings of cardiac, neurologic, and ocular lesions have been previously characterized by Bourquin according to an "embryopathic timetable." This compares the relationship of the date of maternal infection with the maximal differentiation of the organ in the embryo. One difficulty with this hypothesis is the sole reliance on the history from the mother of the date of conception and the time of viremia, both of which are often erroneous.

Other factors which may be of importance in understanding the reasons for tissue specificity include *(1)* the virus dose, *(2)* its ability to be incorporated in the developing organ, and *(3)* the maturity of the immune mechanism of the tissue being infected in the face of an apparently adequate blood antibody response.

Strong evidence for the second factor is the finding that all the positive eye cultures for rubella virus were obtained from patients with ocular disease. No positive eye cultures were found in patients with postrubella syndrome without eye lesions. Bellanti and associates (10), in an autopsy report, showed that a high concentration of the virus was obtained from the lens and the anterior chambers in two children with postrubella syndrome who came to autopsy within the first month of life. The patients in these authors' series had negative lens and anterior chamber cultures, which were done at the time of surgery at the age of six to thirteen months.

In addition to congenital heart defects, mental retardation, and hearing deficit, there are other associated abnormalities which have been reported infrequently in the ophthalmologic literature. Thrombocytopenic purpura has been reported as an incidental finding in the postrubella syndrome by many authors (2, 11-13). It was noted as a common occurrence in the 1964-65 epidemic as reported by Cooper (14). The present study also indicates a high incidence of thrombocytopenic purpura in both ocular and nonocular groups. The platelet count spontaneously returned to normal and was a transient finding in most cases. One child with multiple congenital defects, however, experienced a persistent thrombocytopenic purpura and, at the time of autopsy, had many purpuric lesions.

X-ray changes in the long bones have recently been reported in the postrubella syndrome and are also transitory (15). This had not been described previous to the 1964-65 epidemic. Changes of density of the metaphysis of the long bones and radiolucency of the shaft were seen in two children in this series.

Although the pathogenesis of the ocular damage in the rubella syndrome is entirely speculative, the recent availability of the viral cultures indicates that the embryopathy

of the disorder is secondary to viral invasion of the tissue involved (Table 8) and suggests that, in those patients in whom positive culture has been obtained, there is impressive ocular involvement. The frequently observed damage to the lens and retina is in accord with their rapid maturation at the time of virus infection of the eye.

The iris transillumination and the glaucoma seen in this series may represent either a direct or a secondary effect of the virus infecting the anterior segment. If the glaucoma were secondary to an inflammation of the anterior chamber, one might expect to find peripheral anterior synechiae in the angle, but these findings were not seen on gonioscopy. It is possible that the pathogenesis of the rubella glaucoma is similar to other forms of primary congenital glaucoma. Speculation would naturally pose the possibility that the cause of some apparently idiopathic congenital glaucomas may be directly due to rubella infection during pregnancy or to a similar viral infection capable of inducing teratogenic effects upon the developing chamber angle.

The importance of the viral culture and serologic data to the ophthalmologist and to the medical community in general is graphically shown by comparing the previous understanding of the relationship between rubella infection and congenital defect to conclusions drawn from the present study (Table 9). As recently as 1958, Krugman and Ward (16) gave a 12 percent expectation of any congenital abnormality to a mother having rubella in the first trimester. The present series is biased because it comprises referral cases. However, it is important to note that in this group there was a 49 percent expectation of ocular involvement alone and a high incidence of multiple defects with the ocular lesions. It is imperative to point out that, if one uses the strict criteria of diagnostic proof by culture and/or serology, there is a 100 percent expectation of congenital defect (Table 9).

From this study it is evident that there is a high correlation of congenital ocular abnormalities and the postrubella syndrome. Rubella should be suspected as the causative agent in the investigation of any congenital ocular abnormality, and the laboratory procedures herein described should be obtained. Further, the high incidence of associated multiple defects in the postrubella syndrome when ocular lesions are present should be considered in determining the method of treatment and timing of possible surgical intervention. There is evidence accumulating which indicates that surgery for cataract and glaucoma in this disease should be deferred until the neonatal destructive insult has abated (17, 18).

Table 9

Expectation of Congenital Defects Following Clinical Suspicion of Rubella[a] Compared to Proven Rubella

	Month of Pregnancy in Which Rubella Acquired	No. Surviving Infants	Infants with Congenital Defects No.	%
Lundstrom study				
	1st	115	10	9
	2nd	143	17	12
	3rd	179	16	9
	Controls[b]	676	11	1;6
Present study with culture and/or serology:		49	49	100[c]

[a] *Based on Lundstrom* (19), *a study performed prior to the time when diagnostic studies and antibody titers were available.*

[b] *Pregnant women who did not acquire rubella.*

[c] *Forty-nine percent of these patients had ocular defects.*

Addendum

One infant not included in our series is of particular interest. The mother had received gamma globulin during pregnancy after an exposure to rubella. Evidence for rubella infection in the infant was obtained by serologic testing. These anomalies were observed in the developing neonatal infant: generalized retardation of growth, megalocornea (no family history of megalocornea) as the only ocular abnormality, profound hearing loss, an anomalous ring of the right subclavian artery, an inferiorly displaced left kidney with a double collecting system. Except for the hearing loss, these anomalies were most unusual for the rubella syndrome and suggested that the administration of gamma globulin to the mother may possibly have altered the manifestations of the syndrome.

SUMMARY

1. One hundred five patients born during the 1964-65 rubella epidemic were studied for ophthalmologic defects of congenital rubella infection.

2. Forty-nine patients were found to have the postrubella syndrome by viral culture and/or specific serologic response to the virus.

3. Of proven rubella patients, 49 percent had ocular defects. Data are presented to show the specific ocular findings.

4. Nonocular defects are tabulated according to frequency and to the coexistence of eye lesions. A 96 percent correlation of eye and heart involvement was observed in this series.

5. Viral invasion of the anterior and posterior segments of the eye is suggested by clinical and laboratory evidence.

6. The use of viral cultures and serologic determinations for rubella in the study of congenital ocular defects is discussed.

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A TACTUAL FORM OF THE PROGRESSIVE MATRICES FOR USE WITH BLIND CHILDREN*

Charles C. Rich and Robert P. Anderson

Raven's Colored Progressive Matrices were adapted to a tactual format, thus making possible the insightful solution of the test items without the use of vision. In order to determine the validity of this test as a measure of intelligence in blind children, tactual Progressive Matrices scores of 115 blind students were correlated with WISC Verbal Scale IQ scores, academic achievement, and chronological age. Subjects ranged from 6 to 15 years of age, and all had a 99 percent or greater loss of visual efficiency. The tactual test correlated with validity criteria in a positive and significant manner. Kuder-Richardson reliability of the tactual Progressive Matrices was found to be adequate in children age 9 years and older. It was concluded that this test shows promise as a nonverbal intelligence test for the child of 9 to 15 years of age, but that further development is necessary before it can be considered a useful supplement to the standard tests used with the blind.

Reviews of the status of psychological tests for use with the blind have indicated that there exists a need for a nonverbal intelligence test suitable for administration to blind persons (3, 13, 16). Test development for the blind has largely taken the course of adapting existing tests used with sighted persons to a form acceptable for administration to blind persons (7). Translation of written group tests to braille writing with revision of time limits and normative tables has been satisfactory for use with blind children who can read braille (4, 6, 16). Verbal intelligence tests administered orally are used extensively with the blind without major revision. Specialized tests of aptitudes have been more difficult to devise for the blind, except for tests of motor skills and dexterity (2, 3, 20).

Wattron (21) reported a correlation of .84 between a tactual adaptation of the block design test and Hayes-Binet mental ages. Jones (11) working with Tifflin developed a performance test for the adult blind based on the oddity principle. Correlations between this test and criteria of job success were found to range from .40 to .69, indicating that the test may possess considerable predictive validity. Shurrager (18) developed a performance test similar to the Wechsler Performance Scale. The test correlated .65 with the verbal WAIS.

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Anderson (1) developed a tactual adaptation of Raven's Progressive Matrices (PM) test that is intended to meet the need for a nonverbal intelligence scale for the blind. He attempted to avoid the problem of variable tactual sensitivity in the blind by constructing his version of the PM of heavy materials and by simplifying the stimulus patterns to essential relations. Unpublished results indicate that the Tactual Raven correlates in a statistically significant, positive manner with the WAIS Verbal.

The purpose of this study was to determine whether a tactual adaptation of the Colored Progressive Matrices (CPM) provides a valid measure of intelligence. The validity of the tactual test was evaluated by correlating the subjects' scores with criterion assessments made at the same time that the experimental test was administered. The criterion assessments were: *(1)* scores on the verbal scale of the Wechsler Intelligence Scale for Children, *(2)* teachers' ratings of academic ability, *(3)* grade placement of the child at the time of the test administration, *(4)* chronological age of the subjects, and *(5)* the average grade points earned by the subjects during the preceding year.

THE SAMPLE

The sample was composed of 115 blind children whose ages ranged from 6 to 15 years. The state schools for the blind of Arkansas, California, and Oklahoma, and the public schools of Dallas and Lubbock, Texas, permitted testing of blind subjects.*

The subjects all had vision poorer than 5/200 by the Snellen Index, or the equivalent of a 99 percent loss of full visual acuity. For the majority of subjects the onset of blindness was at birth; only eight subjects lost their vision adventitiously. In the participating schools, all subjects between the ages of 6 and 15 years were screened to eliminate those children whose vision was sufficient to distinguish patterns. The subjects who met this criterion of blindness were tested with the Tactual Progressive Matrices (TPM).

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DESCRIPTION OF THE CHILDREN'S TACTUAL PROGRESSIVE MATRICES

The experimental test (Children's Tactual Progressive Matrices, hereafter CTPM) used in this study consisted of copies of the items included in Raven's CPM: Sets A, Ab, and B (14). Each item consisted of a ground with a raised design, so that the design was tactually perceptible (the matrix), and six pieces or choices with raised designs (the inserts). There were 36 items in the test.

The construction of each item corresponded closely to Raven's items. The dimension of the matrix proper was 7 in. x 4 in., and each insert was 2 in. x 1 1/4 in. in size. The raised designs were constructed of balsa wood, cardboard, and wire. The height of the raised designs was from 1/16 in. to 1/4 in. for different items. The designs were constructed on heavy illustration board.

There was a part missing from the design of each matrix. The task of the subject was to find through tactual exploration and comparison, which of the six inserts would best complete the analogy implicit in the matrix design.

PROCEDURE

The TPM Sets A, Ab, and B and the Verbal Scale of the Wechsler Intelligence Scale for Children were administered to the blind children. In some instances the WISC Verbal could not be readministered, and in this eventuality previous scores obtained on the test were used.

Each child was evaluated by his teacher or school principal on two five-point scales: *(1)* How does this child compare with other blind children of his age in academic ability? *(2)* How well does this child read braille, compared with other blind children of his age? The final grades of each child in the current academic year were taken as a further concurrent criterion of academic ability. The ratings and mean grade-point average were correlated with the CTPM T-scores to obtain an estimate of the validity of the test.

The administration of the CTPM corresponded closely to that method developed by Raven for the board form of his test. All 36 items of the Raven were administered to the subject in one session. There was no time limit, and the subject's score was the number of items correctly completed. The child was asked to solve a series of puzzles that he could perceive by touch, and he was aided in the solution of the first few items. His responses consisted in finding the correct insert, or piece, from among the incorrect inserts, and placing it in the matrix where a portion was missing. His final choice was scored either right or wrong, and the next problem was presented.

Table 1

Means and Standard Deviations of Raw Scores on the CTMP, Sets A, Ab, B, and Total Score for Three Age Levels and Total Group

Set	Age 6-8 (N = 22)	(Age 9-11 (N = 47)	Age 12-15 (N = 46)	Total Sample (N = 115)
A Mean	5.8	6.8	8.0	7.1
SD	1.8	2.2	2.2	2.3
Ab Mean	2.4	5.7	6.9	5.5
SD	1.3	2.8	3.3	3.2
B Mean	2.1	3.4	4.6	3.6
SD	1.4	2.2	2.4	2.4
Total Mean	10.2*	15.8*	19.6*	16.2
SD	2.5	6.2	7.2	6.9

**Mean differences between all pairs significant at the .01 level (Duncan's Range Test).*

RESULTS

Subjects were divided into three groups by age: 6-8 years old, 9-11 years old, and 12-15 years old.

Table 1 shows CTPM raw score means and standard deviations for Sets A, Ab, and B, as well as the total score for each of these three age groups. Mean differences between the total scores for each pair of the three groups were evaluated by Duncan's Range Test, and all paired means were found to differ significantly from one another at the .01 level. The correlation between chronological age and raw scores on the CTPM was found to be .50, $p = .01$.

Sex differences on the TPM and the WISC Verbal were evaluated by t test, and neither difference was significant. The mean WISC Verbal Intelligence quotient was 102.9 for the total sample.

Reliability. Correlations between the three sets of the CTPM indicate moderate homogeneity of the test. The coefficient of correlations between Set A and Set Ab was .64, between Sets A and B, .53 and between Ab and B, .73.

Table 2

Tactual Progressive Matrices Reliability Coefficients for Age Groups and Total Sample

Group	N	Kuder-Richardson (Horst Formula)	Split-Half (Corrected)
Age 6-8	22	.28	.44
Age 9-11	47	.89	.94
Age 12-15	46	.93	.96
Total group	115	.90	.95

Coefficients of reliability are given in Table 2 for each of three age groups and for the total group. Kuder-Richardson correlations were calculated by Horst's (10) modification of the Kuder-Richardson Formula 20, which takes into consideration differences in item difficulty.

The split-half reliability coefficients are reported for comparison and have been corrected by the Spearman-Brown formula.

Validity. Correlation of TPM raw scores and WISC Verbal test ages calculated by the formula method (22) was .53, $p = .01$ for the total sample, indicating a substantial relationship between the two tests. TPM raw scores correlated .53, $p = .01$, with grade placement of the subjects. The WISC Verbal Scale test ages calculated by the formula method correlated .75, $p = .01$ with chronological age and .87, $p = .01$ with grade placement. Correlations between the CTPM raw score and the WISC subtests raw scores were as follows: Information, .33; Comprehension, .40; Arithmetic, .43; Similarities, .24; Vocabulary, .27; and Digit Span, .32. All correlations are significant at the 1 percent level of confidence.

Table 3 shows correlations between standard scores on the CTPM, WISC Verbal intelligence quotient, and validity criteria.

It will be noted that correlations between the WISC Verbal and the validity criteria are higher than those between the CTPM and the same criteria.

Table 3

Correlations Between Tactual Progressive Matrices, T-Scores, WISC Verbal IQs and Validity Criteria in Three Age Groups and in Total Sample

Validity Criteria	Age 6-8 (N = 22)	Age 9-11 (N = 47)	Age 12-15 (N = 46)	Total (N = 115)
CTPM				
Grade-point average	.24	.20	.61	.36
Academic rating	.22	.26	.58	.39
Braille rating	.39	.06	.21	.18
WISC verbal IQ	.46	.25	.32	.31
WISC				
Grade-point average	.42	.47	.58	.51
Academic rating	.58	.58	.73	.64
Braille rating	.66	.50	.46	.50

Standard errors of estimate were calculated for the prediction of grade-point average by the CTPM and the WISC Verbal. The standard error of estimate indicated the accuracy with which the grade-point average may be predicted by each test. These values were .69 for the CTPM, and .64 for the WISC Verbal. Since the standard deviation for grade-point average was .74, the use of either the WISC Verbal or the CTPM to predict grade-point average in the sample would not be appreciably better than chance. The use of these scores alone to predict grade-point average for individual children is unwarranted.

The potential utility of the CTPM and the WISC Verbal as a test bettery was evaluated by calculation of coefficients of multiple correlation. These values for different age groups are given in Table 4.

Multiple correlation coefficients are never lower than the largest correlations between the individual predictor variables and the assessment (12). Since the correlation between the WISC Verbal and grade-point average is .42 for the 6-to-9-year-old group, and .48 for the 9-to-11-year group, the multiple correlation does not improve the degree of correlation with the criteria. In the 12-to-15 group, the multiple correlation appreciably exceeds that of each test alone and indicates that prediction of academic achievement would be improved by combining the scores of the two tests. The standard error of estimate for the multiple correlation coefficient for this group is .51, or approximately one half a grade point.

Table 4

Multiple Correlation Between WISC and Tactual Progressive Matrices and Grade-Point Averages

Age Groups	N	Multiple Correlation Coefficients*
Age 6-8	22	.42
Age 9-11	46	.48
Age 12-15	47	.73
Total Sample	115	.55

**All coefficients significant at .01 level.*

Total Time Necessary to Administer the CTPM. The mean time necessary to administer the tactual test was 40 minutes, with a standard deviation of 18 minutes. The range of total time was from 15 to 105 minutes. The mean amount of time used to administer the test was not objectionable, but the rather large standard deviation indicates that there was a wide variation in the amount of time used by individual subjects. Fourteen percent of the *S*s took over 65 minutes to complete the test. Total time did not correlate significantly with the score on the CTPM, grade placement, grade-point average, or WISC Verbal test age.

Normative Data. Percentile norms are presented in Table 5 in a form comparable to Raven's normative table for the CPM. The values of the norm table presented here are to be taken only as a tentative indication of the distribution of children's scores on the CTPM. A much larger sample of blind children must be tested at each age level before the norms will be useful in clinical work.

Comparison of Table 5 with Raven's norm table for school children on the CPM reveals that blind children's scores on the CTPM are much lower than sighted children's scores on the CPM.

Item validity was obtained by means of bi-serial correlations between each item and *(1)* total score on the CTPM, and *(2)* WISC Verbal test ages. Twenty-two of the 36 items of the CTPM were found to correlate significantly with the validity criteria. Three of these items were too easy to differentiate between levels of mental ability, since 90 percent of the subjects passed the items. These were items A1, A2, and A3. Other items of low validity were too difficult, and only 17 percent or less of the subjects passed these items. These items were A11, A12, Ab12, B8, B10, B11, and B12.

Table 5

Tentative Norms for the CTPM

Percentile	Age 6-8 (N = 22)	Age 9-11 (N = 47)	Age 12-15 (N = 46)
95	14	25	31
90	13	24	30
75	12	19	25
50	10	15	18
25	8	12	13
10	6	7	12
5	...	66	9

QUALITATIVE DATA

Comprehension of the Task. When the blind child was presented with the first item of the CTPM, the immediate response on the part of most of the subjects was to begin a tactual examination of the surface of the board. When the examiner pointed out the part missing in the matrix and indicated that the subject's task was to fill in the missing part with one of the movable pieces at the bottom of the board, the primary inclination of the subjects was to find a piece which fit into the hole in manner similar to that demanded by a jigsaw puzzle. With further explanation and the direction of the subject's attention to the surface of the board, most of the subjects grasped the real nature of the task, and continued to approach each succeeding item with the desired problem-solving set. Some subjects did not seem to grasp the nature of the task, however, and persisted in trying to fit pieces into the hole, or to select a piece which repeated some irrelevant feature of the matrix. It was the opinion of the examiner that motivational factors such as persistence and need for achievement entered into the test situation and determined to no small degree the total score obtained on the test.

Observations on Subjects of Different Ages. The 6- and 7-year-old subjects were observed to have difficulty with the manipulation of the test materials and were generally unsystematic in their search for the correct insert. Almost one half of the subjects of this age had difficulty in comprehending the nature of the task. Approximately one third showed poor memory of the general layout of the puzzle board and showed an inability to locate the slot where the correct piece was to be placed. A majority of these subjects showed emotional reactions to the task that seemed to interfere with the problem-solving process.

By the age of 8 years, approximately one fifth of the subjects approached the matrices in a mature, problem-oriented manner. Difficulty in understanding the nature of the task and the directions, lack of ability to discriminate between parts of the puzzle board, and spatial disorientation were commonly observed in the other 8-year-olds.

At the age of 9 years, 11 of 13 subjects were motivated to do well and enjoyed the task. In general, the 9-year-olds grasped the relationships easily, manipulated the test materials easily and were systematic in their search for the correct choice. There was some indication the 9-year-old children tended to become tired before the end of a series of tests.

Subjects of age 10 and 11 years showed few of the signs of fatigue or boredom, lack of comprehension, and poor manual dexterity that were common among children up through age 8. This was true, however, only with subjects whose intelligence was above the borderline defective range. The suspected mental defective subjects performed like children of the 6- and 7-year-old group.

The blind children of normal intelligence of age 12 worked rapidly, were quick to understand directions, worked with a minimum amount of direction, and had no difficulty in tactually perceiving the test items. They were orderly and systematic in their exploration of the matrix. They showed concern about the adequacy of their performance but this anxiety did not seem to interfere with solution of the problems. Subjects of this age who did not show these traits were suspected to be either emotionally disturbed or immature, or to have intelligence quotients below 85.

The 23 children aged 13 years or older were very similar to the 12-year-old subjects in their reaction to the test.

DISCUSSION

The results of the present study showed that blind children from 9 to 15 years of age were able to solve a number of the tactual problems without undue difficulty. The average scores obtained by blind children on the CTPM were much lower, however, than the average scores of sighted subjects on the printed equivalent of the CTPM. This finding might be taken as an indication of a retardation of the mental development of blind children. Hayes (8) has written that collected evidence seems to indicate that blind children are retarded by at least two years in school work and in the abilities measured by intelligence tests. This conclusion cannot be legitimately drawn from the present data, for there is no evidence that the CTPM is equal in difficulty to the CPM as used with sighted children. Although comparative studies have not yet been carried out, it seems likely that the CTPM is much more difficult than the CPM, largely because it is more difficult to organize tactual cues into meaningful patterns than it is to organize visual cues.

The observations made of the children while they were engaged in solving the tactual matrices indicated that subjects younger than 9 years of age generally showed

an inability to understand the test and manipulate the materials, and that subjects of 9 years of age and older were able to grasp the relationships easily, were systematic in their search for the correct solution, and had good manual dexterity and spatial orientation. Raven (14, 15) found that by the ninth year a qualitative development in ability to solve the Matrices was apparent. Whereas younger children could discover the relationship between simple fundamentals, by the age of 9 children were able to reason by analogy, and from this age onward there was a development of logical thought.

The correlation of the CTPM with the WISC Verbal test ages was substantial, .53, but the correlation of the CTPM with the WISC Verbal IQ was lower, .31. These coefficients indicate a moderate degree of validity for the CTPM as a test of intelligence.

Correlations between the CTPM and academic achievement assessments were consistently lower than those between the WISC Verbal scale and the same criterion assessments, indicating that the verbal abilities measured by the WISC Verbal were more closely related to school achievement than were the abilities measured by the CTPM. Within the group of older children, however, the CTPM and academic assessments correlated highly, and the WISC Verbal and the CTPM scores may be combined to provide an efficient technique for the prediction of grade-point averages of children in the 12-to-15 age group.

Work with factor analysis had generally revealed the presence of a motivational factor that may be equated with personality and interests, or the industriousness which affects all school work. Teacher's ratings and school marks generally show the combined influence of verbal, general, and achievement motive factors. Observation of the blind children in the process of solving the Matrices led to the conclusion that persistence was an important determinant of scores on the test. The hypothesis is advanced that the higher correlation of CTPM scores with academic achievement in the group of older children may be related to the greater capacity of these children to expend concerted efforts toward the solution of the Matrices.

The intercorrelation of Sets A, Ab, and B of the CTPM were lower than the same intercorrelations between the sets of the CPM, indicating that the CTPM has less internal consistency than the Standard Progressive Matrices (SPM). Reliability of the CTPM was found to be unsatisfactory with 6- to 8-year-old children, but the reliability coefficient was of adequate magnitude with children of 9 years of age and older. The reliability of the CTPM corresponds closely with the values obtained with the SPM (5, 24).

The items of the test were too difficult for children through the age of 11 years, but were of satisfactory difficulty for children of 12 to 15 years of age. The distribution of items over the range of difficulty was found to be most satisfactory with the older subjects, but generally the items were not evenly spaced along the difficulty continuum.

The mean scores obtained by the sexes on the CTPM did not differ significantly. The finding of no sex differences in the performance of the SPM had been reported by Raven. Rowley (17) studied tactual formboard performance of sighted children as a function of age and sex, and found no significant sex differences.

It is readily apparent that future experimentation on the test should involve samples that are homogeneous for age and education, but heterogeneous for ability or achievement. The present results reflect the need for continued research before the tactual test can be used on a clinical basis.

CONCLUSIONS

1. A tactual form of Raven's Progressive Matrices may be successfully administered to blind children above 8 years of age.

2. High reliability and moderate validity coefficients suggest that the test can be used on an experimental basis as an adjunct to verbal tests of intelligence.

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FACTORS ASSOCIATED WITH INTELLECTUAL VARIATION AMONG VISUALLY IMPAIRED CHILDREN*

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The intelligence of blind children has been subject to a number of studies since the 1914 adaptation of the Binet scales by Irwin and Goddard (6). However, the interpretation of the meaning of intelligence test scores obtained from blind children in relation to underlying developmental, accidental, or social factors remains controversial.

Among blind persons intelligence has been found to be positively associated with personal adjustment (1), with number of years of education (7, 8, 9, 13), and negatively with occipital brain lesions (14). No relationship with intelligence was found among precipitating adventitious and congenital factors, age at the time of loss of sight, or extent of blindness (5, 8, 9). These conclusions were partially supported by Bauman (1), who also found intelligence unrelated to suddenness or recency of loss of sight. Also, Bauman found a qualified negative relationship between amount of vision and intelligence.

PROBLEM

Hollinshead (10) has discussed two components of psychological variation among physically disabled persons: (a) the somatopsychological, stressing the component of social reaction to disability as a major determinant of psychological variation, and (b) the intrinsic physical limitation itself, apart from social considerations. While not denying the importance of social-psychological factors, Hollinshead has suggested that insufficient attention has been given the limiting aspects of a disability *per se.* In relation to these two components of variation the previously cited research on factors associated with intelligence among blind persons would appear to be most consistent with hypotheses favoring social determiners of intellectual variation rather than direct physical determiners. While these two influences are difficult, if not impossible, to dissect precisely from each other, conditions can be arranged that should allow primary observation of

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the effects of one component (for example, direct physical influence) while the effects of the other (for example, social reactions) are more randomly parceled out.

METHODOLOGY AND HYPOTHESIS

Records at the Michigan State School for the Blind permitted the testing of hypotheses related to the following concepts: (a) that intelligence varies directly with certain physical variations in blindness, and (b) that intelligence varies according to social-psychological influences.

Three hypotheses were constructed to examine the "direct physical" aspect of intellectual variation:

1. Intelligence of blind subjects will vary directly with the age of onset of blindness. The later the onset of blindness, the higher will be the intelligence.

2. Intelligence of blind subjects will vary inversely with the degree of blindness. The greater the degree of blindness, the lower will be the intelligence.

3. The intelligence of blind subjects will vary according to the cause of blindness.

Four hypotheses were constructed to examine the "social influence" aspect of intellectual variation:

4. Blind subjects with a history of blindness in the family will score a lower IQ than blind subjects with no such family history (family is defined as parents, siblings, and grandparents).

5. The intelligence of blind subjects will vary directly with the ranking of the years of education prior to the testing; the more years of education, the higher will be the intelligence.

6. The intelligence of blind subjects will vary directly with the social class attained by their parents; the higher the social classes of the parents, the higher will be the subjects' intelligence.

7. Intelligence of blind subjects will vary inversely with (a) their sibling position in the family and (b) the number of siblings—that is, the earlier the birth rank in the family and the fewer siblings the subject has, the higher should be the subject's IQ.

The following information was obtained by studying each student's scholastic, psychological, and medical files: (a) date of birth; (b) history of blindness in the subject's family (parents, siblings, grandparents); (c) number of years spent in other schools; (d) intelligence test scores (kind of test, chronological age, mental age); (e) cause of

blindness; (f) degree of blindness; (g) type of onset (progressive or traumatic); (h) age at onset of blindness; (i) date enrolled in residential school; (j) number of years in school when intelligence tests were given; (k) father's occupation; and (l) number of siblings and placement of blind student in family.

Four intelligence tests have been used at the Michigan School for the Blind—the Interim Hayes Binet, the verbal scales of the Wechsler-Bellevue 1 and of the Wechsler Intelligence Scale for Adults. Hayes (8) has reported correlation coefficients in the range of .80 to .95 between the Interim Hayes Binet and the Wechsler-Bellevue verbal scales. These tests were assumed to yield comparable IQ scores for the purpose of this study.

Causes of blindness were grouped under nine categories: (a) insult to eye, head, or brain; (b) congenital defects; (c) eye or brain tumor; (d) inflammation or infection of eye or body; (e) cataracts; (f) retrolental fibroplasia; (g) optic atrophy; (h) myopia, albinism, nystagmus, and strabismus; and (i) glaucoma.

The degree of blindness was coded using the criteria established by the Committee on Statistics of the Blind and summarized below:

1. Totally blind
2. Motion or form perception
3. Travel vision
4. Vision to read large headlines
5. Borderline vision (3)

The father's occupation for each student was coded using Warner's Index of Status Characteristics (17) and thus grouped into upper, middle, and lower divisions.

The 253 subjects used in this investigation represented the entire population of the Michigan School for the Blind in 1958-59. There were 150 males and 103 females. At the time of the investigation ages ranged from 6 to 18 years and grades ranged from one through twelve.

Intelligence test results were taken from school records. Testing was done by both supervised graduate students from Michigan State University and by psychologists attached to the Michigan School for the Blind or employed by the state of Michigan as consultants. Although most of the children had been tested within three years prior to this study, it was necessary to use older test results in some cases.

Scores for male and female have been combined for all measures because no differences were found between these groups in respect to intelligence (nonsignificant *t*-test).

RESULTS AND DISCUSSION

1. The first hypothesis suggested that intelligence would be directly related to age of onset of blindness, under the supposition that if blindness is detrimental to the development of intelligence, the earlier that blindness occurs, the greater should be the intellectual deficit. Because of incompleteness of available data, it was necessary to dichotomize age of onset into congenital and acquired categories. The obtained one-tailed *t*-value used to test differences in mean intelligence scores for the two groups was nonsignificant. This finding is consistent with results reported by both Hayes and Bauman.

There seems to be no convincing evidence that blindness acquired at or before birth has a retarding effect on intellectual development. The data considered under hypothesis 3 would lend support to this conclusion.

2. The second hypothesis suggested that amount of vision would be directly related to intelligence, under the supposition that the more limited the person's vision, the more limited would be the opportunities for environmental organization and to some extent for interpersonal interaction (15).

Table 1 indicates that no significant correlation was found between intelligence and amount of vision. An analysis of variance test of intelligence score means distributed among categories of amount of blindness was significant ($p = .05$). However, the interpretation of this finding would be highly speculative. The highest IQ mean was found within the second most severely disabled group, whereas a group with lower vision obtained the lowest mean IQ.

These findings would suggest that blindness, in itself, may not be as handicapping as the ambiguity of the limitations of blindness when coupled to the awareness of, and perhaps competition with, the sighted world.

Table 1

*Degrees of Blindness, as Related to Mean IQ Scores**

Degree	N	Mean IQ
Up to 2/200	122	96.80
Up to 5/200	20	100.30
Up to 10/200	22	93.04
Up to 20/200	62	95.90
20/200 or less	27	97.00
	253	

**See page 63 for the definition of degrees of blindness.*

3. The third hypothesis suggested that the cause of blindness would be related to differences of intelligence, under the assumption that varying degrees of Central Nervous System (CNS) involvement would be reflected within the various etiological categories. Table 2 revealed no significant mean differences among etiological groups when considered independently of CNS versus non-CNS peripheral effects and socioeconomic class. However, when individuals were classified according to CNS versus non-CNS peripheral causes of blindness a significant *t*-value was obtained ($p = .01$) between the two groups, suggesting that blindness *per se* is not as handicapping to intellectual development as actual brain injury.

Table 2

Analysis of Variance of IQ Means of Different Socioeconomic Groups and Different Causes of Blindness

Source of Variation	Sum of Squares	d.f.	M.S.	F
Socioeconomic (SE)	1,084.94	2	542.47	1.30
Cause of blindness (CB)	4,710.87	8	588.86	1.41
SE x CB*	4,289.80	16	268.11	–
Within	96,481.47	226	426.91	
Total	106,567.08	252	422.88	
Error/term	100,771.269	242	416.41	

**SE x CB within.*

SOCIAL-PSYCHOLOGICAL EFFECTS

4. The implication of hypothesis 4 is that blindness in the immediate family functions to depress IQ scores. A rationale for this hypothesis is found in Bauman (1) who investigated consanguinity in relation to marriage and adjustment of adult blind persons.

Table 3 supports the hypothesis ($p = .05$). A potentially valuable field for further research would appear to reside in the area of interaction between family social structure, personality, and intelligence. Another area of investigation is in the difference in stress within the family associated with frequency of disability. If blindness produces stress on the family, more than one blind person in the family may produce additional stress, causing the family to function less adaptively.

Table 3

History of Blindness in Family as Related to IQ

Classification	N	Mean IQ	SD	
Blindness in family	68	92.75	19.38	P .05
No blindness in family	185	97.70	20.85	
Total	253			

5. Hypothesis 5 expressed the expectation that amount of education is directly related to intelligence. Wechsler (18) has reported that this kind of relationship "is well established." Studies by Komisar and MacDonnel (13), Blank (2), and Cutsforth (4) agree.

The findings were as expected. Table 4 indicates a small but significant positive correlation (Pearson product-moment $r = 16$, $p = .01$) between individual IQ scores and months of education. However, in the absence of control conditions, it is impossible to know what underlies the obtained relationship. It may reflect educational influences, delayed maturation, general environmental changes (for example, home to institution), or perhaps increased peer group acceptance (for example, improved self-concept).

6. Findings on intelligence and social class have revealed characteristic class differences in mean intelligence scores, with higher scores expected among higher socioeconomic groups (11, p. 337). It was predicted that this relationship would also be obtained here; however, the differences among IQ means of the three social classes were nonsignificant. Table 5 indicates a trend toward higher IQ with increased socioeconomic status, and had there been a slightly larger sample of children in the high social class category (N = 15) with the means remaining as found, the differences would have been significant.

7. It has been generally found and accepted that children from small families obtain somewhat higher IQ scores than children with many siblings (11, pp. 341-3). However, this was not found in the present study. Neither did birth rank in the family have any relationship to intelligence. Hunt has suggested (11, p. 343), that intellectual growth is essentially dependent upon early stimulation, and that findings on family size and intelligence may be explained by assuming a lesser degree of early stimulation from adults in large families. A factor to consider for the present study is the leveling effect of institutional life, which may dull the highs and lows of social class and sibling rank.

Table 4

Subjects by Number of Years in School and Mean Chronological Age at Time of Intelligence Testing

Years in School	N	Age in Years Mean	SD	Range	IQ Mean	SD	Range
0-1	31	8.12	3.26	5-2–16-0	89.77	21.02	50-131
2	30	7.75	2.44	5-5–16-10	94.43	17.11	47-122
3	32	9.63	2.46	5-11–16-11	96.12	14.41	53-126
4	21	9.48	1.01	8-0–13-6	86.71	24.41	30-133
5	25	10.68	1.46	8-8–14-6	99.16	21.55	59-147
6	31	12.30	1.47	10-0–16-6	105.51	23.57	31-137
7	17	14.02	1.05	11-5–15-11	97.82	23.26	62-142
8	20	14.24	1.35	12-2–18-7	93.15	16-85	65-115
9	22	15.51	1.89	13-4–18-7	97.04	16.72	66-126
10-11	24	15.58	1.42	15-0–17-10	103.50	20.00	77-123
Total	253	11.40	2.55		96.09	20.56	

Table 5

A Comparison Between Expected and Obtained Percent in Three Socioeconomic Classes

Class*	Expected (percent in total population)	Obtained (percent of subjects)	Mean IQ of Subjects
Upper 1–2	5.0	5.9	103.66
Middle 3–4–5	38.0	33.6	97.42
Lower 6–7	57.0	60.5	94.58

**According to W. L. Warner's (17) system. Numbers refer to Warner's classes.*

CONCLUSIONS

In evaluating the previous discussions and the summary below, a limitation of the method of research used should be pointed out. There is usually a certain amount of "slop" in the use of institutional records for research, of which the investigators met with their share in this study in the form of missing or incomplete data, or data sometimes difficult to interpret.

Considering such limitations, the investigators advance the following cautious conclusions. First, the data tend to support the position that disability (specifically intellectual disability in this study) among blind persons is more affected by their social experiences than by the sensory limitation in itself (16, 19). The two factors that should have revealed the influence of direct sensory effects most clearly, time of onset and extent of blindness, were uncorrelated with intelligence. Further, when blind persons were placed into categories according to amount of vision, it was found that those of intermediate loss had the lowest mean IQ scores. The only physical variation apparently associated with reduced IQ scores was that obtained when blindness was caused by central (CNS) involvement rather than peripheral factors, and thus appears to reflect neurological impairment rather than sensory deficit.

A second consideration involves the relative effects of different social-psychological variables. Our data suggest three significant areas of influence—family structure, education, and attitudes. In regard to family structure, the finding that blindness in the immediate family was associated with lowered IQ scores might plausibly be interpreted in the context of total stress on the family or as resulting from inadequate parental education. Either factor could operate to reduce intellectual stimulation. However, not enough is known about the effects of family function and structure on child growth to suggest a "most probably" explanation.

In regard to educational effects, the findings of increase in IQ with number of years in school, while contributing to our main research interests, is not very helpful to the educator. Whether formal education, informal social experiences, a delayed maturation of intellect, or some other consideration or combination of considerations underscored these gains is a moot point. One approach to clarification of these questions might be the comparative study of residential and integrated day-school placements, where both social and academic experiences may differ in some classifiable or measurable way.

Finally, the inconclusive findings in respect to socioeconomic differences and family size, as compared to the differences that were expected from data in the sighted population, lead us to the area of attitudes. Both societal and familial attitudes toward the blind may structure and direct behavior so as to obscure differential influences of social class and family size that are ordinarily found among the sighted. A second possibility for our sample is that the institutional climate may have blunted and obscured the effects of earlier differential experiences reflecting social class and family size differences.

SUMMARY

Through institutional records an attempt was made to determine the relative influences on intelligence of direct sensory effects and of social-psychological variables. None of the "direct-sensory" hypotheses were confirmed. Reduced IQ scores were found to be associated with neurological impairment, with the presence of blindness in others of the immediate family, and with limited number of years in school. Predicted association between lower IQ, low socioeconomic status, and large family size were not found. Results were interpreted to support the primacy of social-psychological factors as determiners of IQ score differences among blind subjects. Suggestions were made as to the type of research needed to help resolve further problems.

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A MULTIPURPOSE SENSORY AID FOR THE BLIND: REPORT ON A FIELD TRIAL 1965-66

Abraham Wexler

PURPOSE OF THE TRIALS

An instrument basically similar to that reported on here has been in use since 1958 for the specific purpose of enabling blind students to do experimental work in science. This bench model, described on page 96 of *Experimental Science for the Blind,* was made by Ralph Herman, a research engineer in electronics. Its use is now well established in a science class for the blind at the author's home and in the following schools:

Worcester College for the Blind (RNIB)
Chorley Wood College for Blind Girls (RNIB)
L.C.C. Linden Lodge School for the Blind, London
Zoshigaya School for the Blind, Sydney
Narbethong School for the Blind, Queensland

The instrument has proved to be the most versatile of the many specialized devices made for science laboratories for the blind.

These field trials had three goals. The most important was to find out whether and to what extent an instrument of this type would be useful to blind people for more general purposes than experimental science. The author also wanted blind users to criticize the design of the instrument and to suggest improvements. Finally, he wanted blind users to indicate whether such a device should be made readily available to the blind community. (The instrument was designed for the pocket in two senses: to be carried therein and to be as inexpensive as desired performance permits.)

DESCRIPTION OF THE INSTRUMENT

In general terms the device may be described as an audible conductance indicator. The equipment consists of *(1)* a transistorized blocking oscillator (see Fig. 1); *(2)* a crystal earpiece with flex and jack connector; and *(3)* a calcium sulphide-selenide photoconductive cell, Type SP5 (Photronic Controls, Ltd.), fitted into a brass tube with two interchangeable conical caps and flex.

*Mr. Wexler, *an industrial chemist by profession, is the author of* Experimental Science for the Blind *(New York and London, Oxford and Pergamon Press, 1961).*

The oscillator is housed in a plastic container (outside dimensions, 3-1/2 x 1-1/4 x 3/4 in.) which is fitted externally with a jack for the earpiece and with two brass screws on terminals. When a conducting path is connected across the two terminals, a series of pulses is heard in the earpiece, the frequency of which is proportional to the conductance. With a resistance of 10 megohms (M Ω) across the terminals the frequency of the pulses is approximately 12/sec. The 20,000-ohm resistance in the circuit limits the frequency to a maximum 6,000 pulses per second (pps) and the current to a maximum of 0.6 millamperes (mA).

The oscillator is powered by a 1.5-V dry cell. With the photoconductive cell connected across the terminals of the oscillator, the light from a candle 20 ft from the unprotected surface of the cell produces clicks at the rate of 2/sec. This sensitivity permits the cell to be used as a light probe if it is covered by a tapered aperture. In bright daylight or under an electric lamp the aperture can be made as small as 1/64 in. in diameter and still admit enough light to get an audible response from light reflected from a white surface.

RB 15

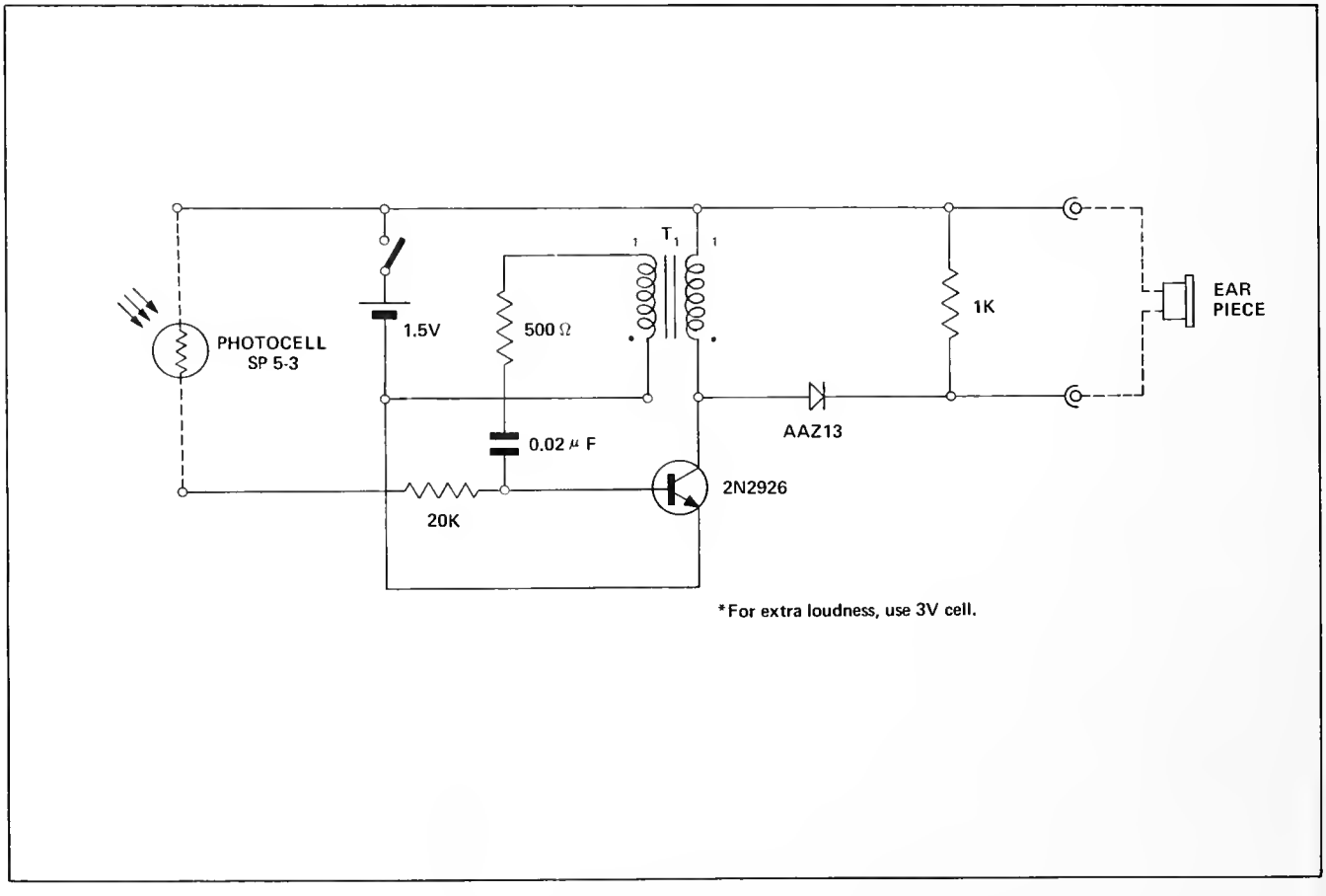

Figure 1. Audible Conductance Indicator

The apertures of the two conical caps provided are 1/10 in. and 1/16 in. in diameter. A length of dual flex and removable color filters also were supplied.

The twelve-page descriptive pamphlet included (a) a nontechnical explanation of the function of the instrument; (b) suggested simple experiments illustrating its uses as conductance indicator and as light probe; (c) a brief discussion of its use for color matching; and (d) a summary of established uses of the device. Reading this descriptive pamphlet might serve as a useful introduction to this report. (See Appendix 1.)

After the equipment was distributed, a brief questionnaire was mailed to the recipients. (See Appendix 2.)

RESULTS OF THE TRIALS

This summary is based upon the opinions of 28 blind persons, nine of whom were associated with the Massachusetts Institute of Technology (MIT) Sensory Aids Evaluation and Development Center (SAEADC). Answers were received from:

Professor T. A. Benham, Science for the Blind, Haverford, Pa.
Chorley Wood College for Blind Girls, RNIB, England
Mr. and Mrs. Dickinson, blind users, Brisbane, Australia
J. K. Dupress, Director, SAEADC, MIT, Cambridge, Mass.
R. Hallet, Secretary to the Association of Blind Citizens, Sydney, Australia
David Henderson, blind physicist, Philadelphia, Pa.
Leo M. Levens, AFB, New York, N.Y.
Professor T. J. Linville, Chairman, Department of Electrical Engineering, Stanford University, Stanford, Calif.
S. C. Mottershaw, blind physiotherapist, Sydney, Australia
T. Mulroney, teacher of science to the blind, Brisbane, Australia
Narbethong School for the Blind, Queensland, Australia
Frank Nolan, blind solicitor, Melbourne, Australia
Mrs. Mira Slade, blind translator, Melbourne, Australia
W. T. Turnbull, blind electronics engineer, Sydney, Australia
J. C. Swail, National Research Council, Ottawa, Canada
Neil Westh, blind teacher, Melbourne, Australia
Worcester College for the Blind, RNIB, England

In many cases the reply to the questionnaire was supplemented by helpful comments on details of use, criticisms of the design, and suggestions for improvement. Mr. Dupress' comments were particularly valuable because they reflect the opinions of nine blind users at MIT. In reporting on the replies I cannot do better than reproduce the short note from Mr. Dupress; many of his suggestions have been incorporated in alternative design of the instrument to be described below. (See Appendix 3 for his comments.)

General Usefulness

Sixteen persons answered "useful on many occasions," twelve replied "useful on rare occasions." This question was not too well framed. What one would like to know is how much importance the blind user attaches to the possession of the device. Four people volunteered the information that they found the device useful in their daily work (see below).

Easy (or Difficult) to Use?

Opinions on this matter were evenly divided: fourteen found that the device as supplied was easy to use and fourteen found it difficult. This question elicited information that revealed weaknesses in the design. The following were the main adverse criticisms:

1. Some reported that the long flexible leads connecting light probe and earpiece to the oscillator became entangled.

2. Some found the brass screw-on terminal connectors and the screw-on conical caps awkward to use. These bits were apt to get lost. (See A. Clark's letter in Appendix 4.)

3. The instrument required too much "fiddling about." Professor Benham made this point forcibly, writing that "The instrument could be good if you got rid of the monkey business."

4. The brass tube housing the photo cell was unnecessarily heavy.

5. The earpiece was difficult to keep in place in the ear.

6. Breakages occurred in leads to earpiece and jack.

7. The photocell was not securely fixed to probe; several breakages occurred in the operation of changing the nozzles.

8. Blind users found it difficult to open the case to insert a new dry cell. Breakages in oscillator circuit occurred.

9. Separate color filters were too flimsy, awkward to use, and easy to lose.

Retain or Return

All but two wished to retain the instrument.

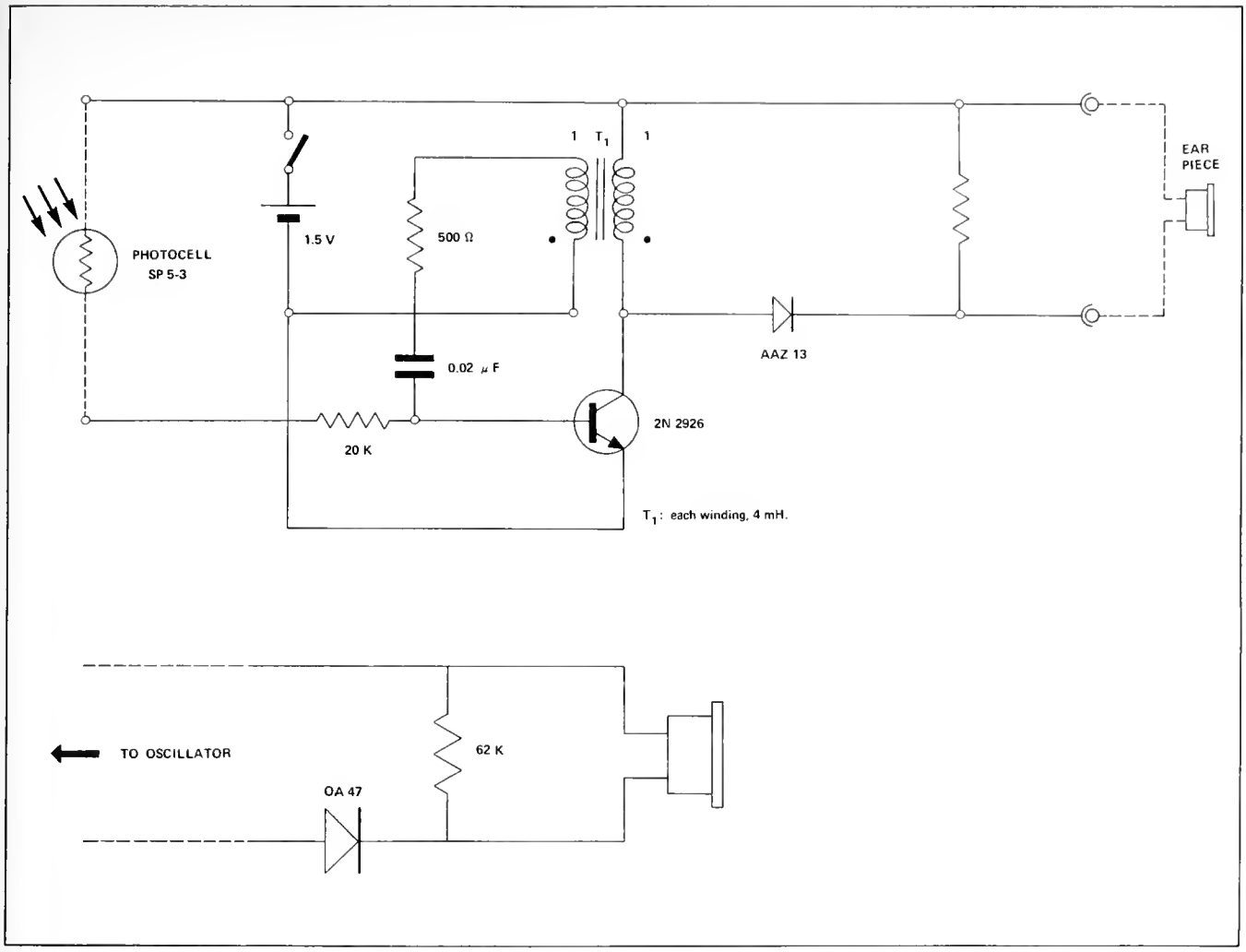

Figure 2. Audible Conductance Indicator: Revised Design

Specified Uses

All replied that they could use the light probe for locating sources of light such as windows, lamps, and bright surfaces. Only three reported success in using the device for distinguishing colors (see discussion below). Sixteen found the device useful for determining liquid levels with the contact probe. Four people were able to use it for identifying values of resistors.

Availability

All indicated that a device of this type should be made readily available to the blind community.

Other Uses Reported

1. Circuit continuity indicator to find out, for example, which of a series of fuse wires has broken (D. Henderson).

2. A humidity indicator using specially impregnated paper connected to terminals of the oscillator (this ingenious application suggested by Frank Nolan).

3. Reading IBM punched cards (D. Henderson).

4. Picking out ripe red tomatoes from the green on plant (Mrs. M. Slade).

5. Reading an oscilloscope (W. T. Turnbull).

6. Reading the "magic eye" on instruments; it was necessary to use a larger aperture to admit more light to photocell (W. T. Turnbull).

7. Distinguishing print or typing (not by reading it) from the blank part of white paper.

8. Finding the position of a magnet under the glass in a pocket compass.

9. Finding the position of a magnet under the glass in a pocket compass.

10. Looking at the sky to see whether it was a dull or bright day. (Frank Nolan reports that he could pick out large clouds in the sky and also "see" lightning flashes in a storm.

11. In photographic work. Blind darkroom operators at Kodak (Melbourne factory) have used the oscillator and probe in conjunction with a microammeter for measuring optical density of film.

Various applications of the device in connection with practical science are summarized in the descriptive pamphlet.

DISCUSSION

Instrument Design

As explained in the descriptive pamphlet, the basic function of the instrument is to provide an audible indication of electrical conductance. This property can be put to a variety of uses: hence the description of the device as a multipurpose sensory aid for the blind.

An instrument that has many different uses is certainly attractive. Unfortunately, it tends to be incompatible with another property people look for in instrumental aids, namely instant usability. Much of the adverse criticism in the replies stems from this conflict between multiple usage and instant usability. The objective of instant usability is much more readily achieved in instruments designed to perform one operation than in those that are polyfunctional.

The device distributed in this field trial was not engineered as a final product for instant usability but rather as an experimental means for getting knowledge. We sought information as to whether this type of device could be more generally useful to blind people than in the science laboratories. From this point of view the field trial achieved a certain measure of success, and as a bonus we received many valuable suggestions which lead to an improved design. Thanks to the able assistance of my colleague, C. Mc Combie, one of the original instruments has been remodeled to incorporate many of these suggestions. (See Fig. 2.) The main design modifications include:

1. The photocell (P) is fixed rigidly to the oscillator.

2. A lamp is included in the equipment and arranged to provide shadowless illumination of the position of the surface being examined by the light probe.

3. The sound signal from the ear piece (E) has been made louder to permit hearing at a distance. Under normal conditions the earpiece is used in the fixed position on the instrument, but it can also be used in the ear.

4. Separate switches (S and O) are provided for the lamp and for the oscillator circuit.

5. A rotatable disc with three color filters (F) and one clear sector is provided to illuminate with different colors.

6. Spring loaded terminal connectors (I) are provided in place of the screw-on terminals.

7. A stand is provided to enable the light probe and lamp to be held in a fixed position relative to the object under observation.

Comments on the Modified Design

Appearance

Admittedly, this is not a thing of beauty. One of my grandchildren wanted to know if it was intended to be a model of a "Luny" (which seems now to be a general term for a visitor from outer space). The esthetically offending part is the angular protruding probe which suggests a snout. This arrangement was found necessary to obtain optimum sensitivity of response from reflecting surfaces using the lamp for illumination.

The Built-in Lamp

Though this is a convenience for applications of the probe where such illumination is necessary, it is not without disadvantages.

When fitted the small prefocus-type torch lamp consumes a current of about 0.2 A, whereas the oscillator circuit with the photocell connected consumes current of the order of 0.2 mA. Without the lamp in circuit the dry cell can last for years without renewal, but with the lamp it runs out in a matter of hours. Moreover, as the battery runs down, the voltage drop due to the lamp in circuit gets progressively greater because of the lowered resistance of the colder lamp filament. This voltage drop causes progressive loss in signal strength.

It seems necessary, therefore, to use a separate power source for the lamp, or alternatively to power it with rechargeable cells which involves providing a rectifier and thus adding to the cost of the equipment. For this reason I am inclined to favor the simplest and cheapest solution to this problem—illumination by a separate lamp and battery. Two important practical examples illustrating this approach follow.

Use of Light Probe for Reading of Instrument Pointer

With the arrangement illustrated in Figure 3, a blind person can read the position of the pointer on an instrument scale with the same degree of precision as a sighted person.

S_1 is the scale of the ammeter; S_2 is the embossed scale, which is a fivefold magnification of the original scale. P_1 is the original instrument scale (see lower diagram).

P_2 is the lever arm (about 8 1/2 in. long) which is pivoted above the instrument case to locate about a center, C_2 which is vertically above the center of location of P_1

L is a small prefocus lamp mounted on the lever arm to give oblique illumination of a white line fixed through middle of P_1

Ph is a small photronic cell (SP53) mounted on the lever arm in position to give a signal into the oscillator from the light reflected from the white thread in P_1

E leads to large 1.5-V battery and switch.

D shows the flexible leads to terminals of the oscillator. The section of S_1 underneath the photocell is blackened. With this arrangement no sound is heard from the oscillator earpiece until the tapered aperture of the photocell housing is vertically over the white line on the instrument pointer.

The embossed scale S_2 on the instrument illustrated has 100 divisions distanced 1/8 in. from each other. The scale divisions on the original instrument are

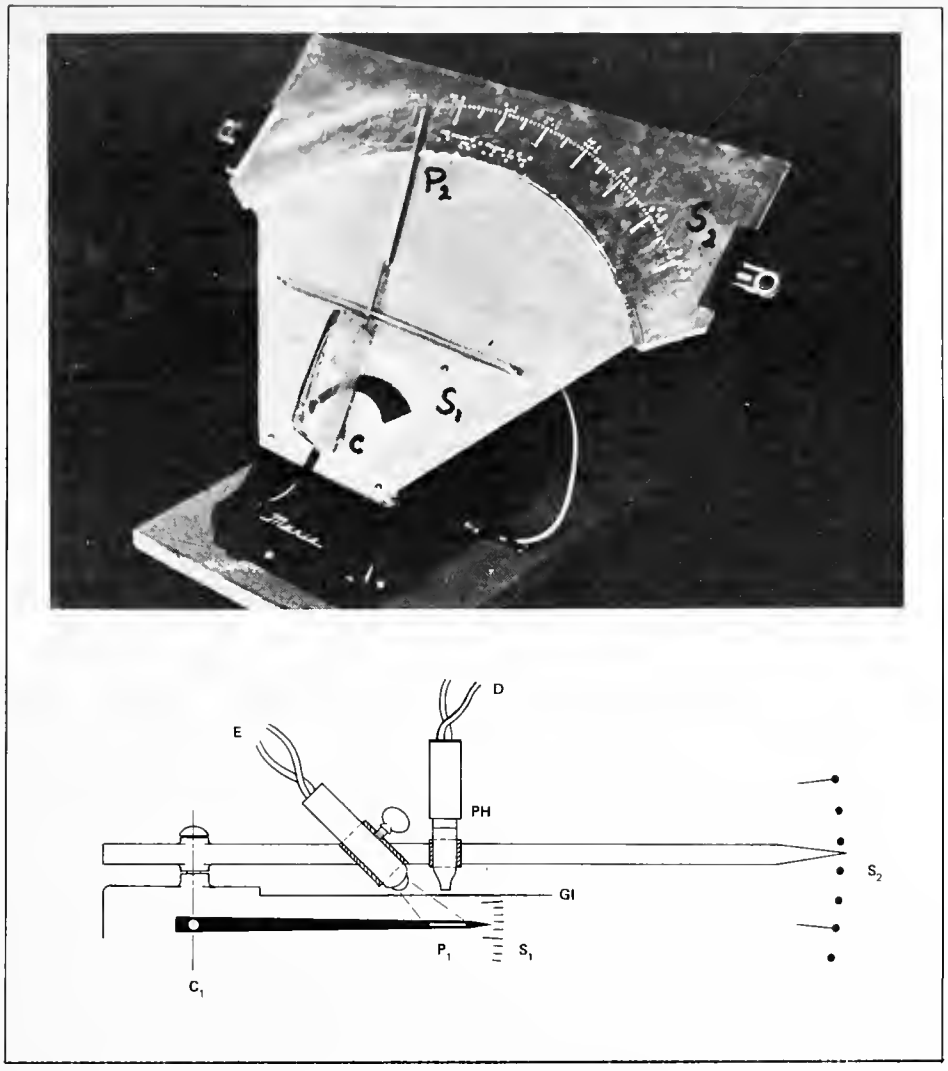

Figure 3. Using the Probe to Read Instrument Pointers

0.025 in. apart and therefore cannot be tactually discriminated without this magnification.

There are many alternative methods for adapting electrical instruments for the use of the blind. The arrangement described above has been used without trouble for some years both in the laboratory and in industry. It has the following advantages: *(1)* it is easy to make by an amateur craftsman; *(2)* its use is not limited to electrical meters but is equally applicable to all pointer-reading instruments.

Because the oscillator and earpiece are available for other uses, the cost of the components is limited to that of the lamp and photocell—approximately two dollars.

Arrangement for Color-Matching Observations with the Light Probe

In considering the problem of the use of the probe for color information, it is important to have in mind a clear distinction between two very different problems—

that of color identification and that of color matching. The first problem implies finding the answer to the question "What is the color of this surface or light source?" There is no simple solution to this problem using the light probe with the oscillator, and I am not yet in a position to recommend its use for this purpose. However, Ralph Herman has suggested that color be identified by means of a series of observations using the light probe with the aid of color filters and a calibrated chart of shades of gray. It is to be hoped that Herman will publish the results of his theory and experiments.

The second problem, color matching, implies finding an answer to the question: "Is the color of X the same as or different from that of Y?" With this type of color problem the light probe can be of assistance to a blind person.

Two conditions are necessary for success: *(1)* equal conditions of illumination of the two surfaces to be compared; *(2)* equal distance and angular direction of the probe with respect to the two surfaces to be compared.

Figure 4 illustrates the arrangement of probe and lamp setup to enable blind diabetics to carry out the Tes-Tape color test for glucose. The base B is a piece of timber 6 x 3 x 1/2 in. A pocket torch is fitted with a prefocused lamp which provides a beam of light. The torch T is fixed in position by means of the grub screw G to illuminate the surface immediately below the probe P which is held in position by the clothes pin. H is a stiff card which holds the sample of Tes-Tape S adjacent to the strip ST which contains a series of patches in different shades of green (corresponding to the color strip provided in the Tes-Tape equipment).

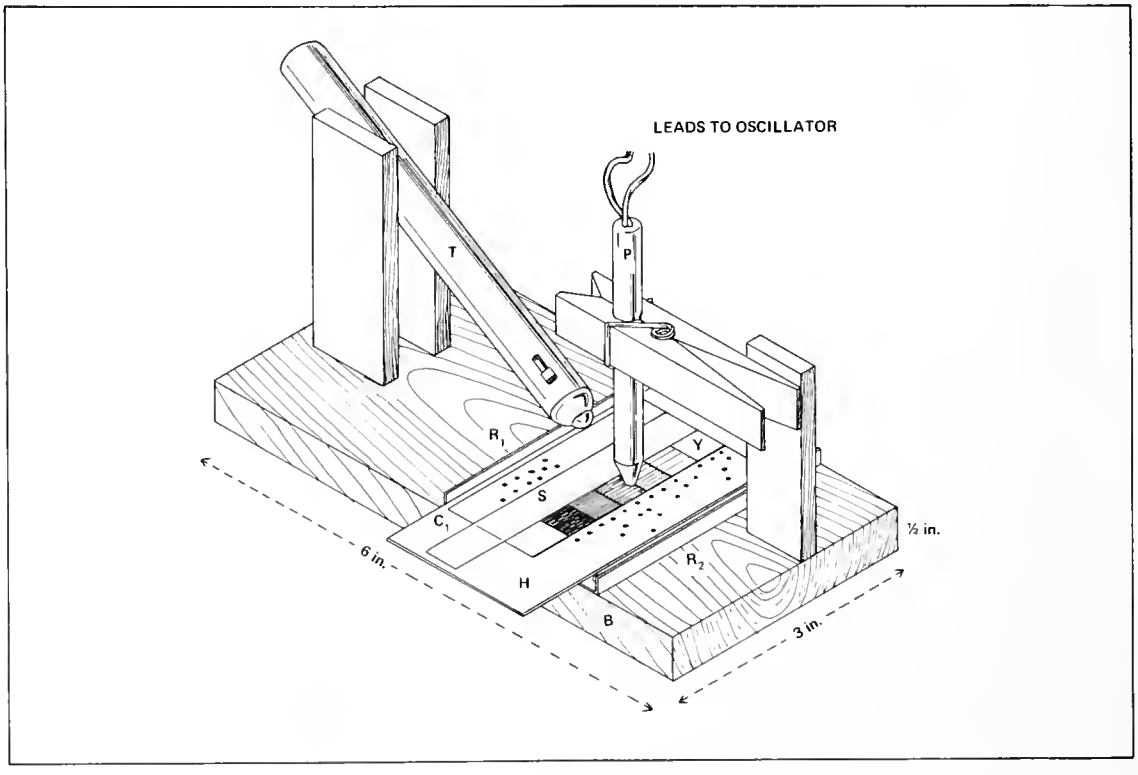

Figure 4. Using the Probe to Match Colors

In the absence of glucose the Tes-Tape sample remains yellow. The different shades of green correspond to the colors produced by different concentrations of glucose in the sample tested. These percentages are embossed in braille on the card H. R_1 and R_2 are raised guiderails which permit the card H to be moved forward and from side to side, so that the response from each color patch on ST can be compared with that from S. A set of color filters can be provided with this equipment, but they are not required in this particular color problem because we are restricted to matching shades of green.

The determination of glucose level with this equipment is rapid and equals in precision the result obtained by vision. Color matching is achieved by finding the positions of the card at which the two frequency responses in the earpiece are most nearly equal. The practiced observer can learn to get a good approximation by recognizing the pitch of the note from the test sample alone. This implies constant intensity of illumination which is not guaranteed by a lamp powered from a dry cell. In this case it would be better to use a small low-voltage lamp powered by a transformer off the main supply.

A variety of color-matching problems that are of practical importance can be solved by methods analogous to that in the example described above. It must be emphasized, however, that in regard to color the light probe is not a simple "look and say" device. For reliable information each color problem of this type requires setting up an apparatus assembly specialized for dealing rapidly with that one problem.

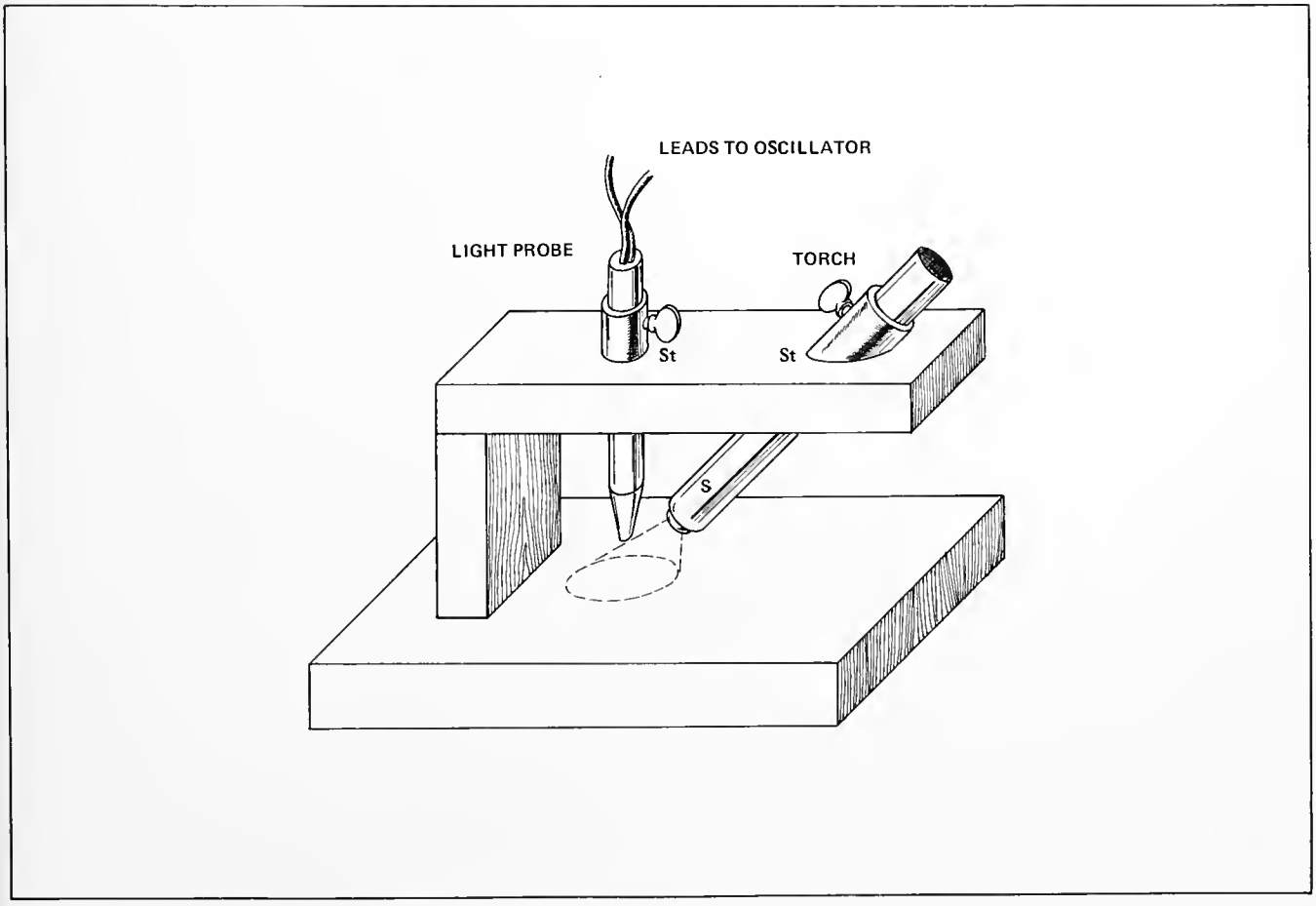

Figure 5. An Alternative Probe Holder

Figure 5 illustrates as alternative arrangement for holding the probe and torch in fixed relative positions. This has certain obvious advantages over the arrangement in Figure 4. Hopefully, the sketch will be self-explanatory. Both light probe and torch are removable, hence the provision of the adjustable stop rings ST.

SUMMARY AND CONCLUSIONS

The author believes that this field trial had a measure of success in fulfilling its major objective—to advance the state of knowledge concerning the potentialities of a device of the type submitted as an instrumental aid for the blind. In addition to yielding information concerning miscellaneous new uses of the instrument, both as light-intensity indicator and as conductance indicator, the trial also revealed certain weaknesses in instrument design. Valuable suggestions for improvement in design were directed mainly to enhancing facility of usage in the hands of blind people.

The trial also has stimulated thought, not only about this instrument but also about certain general problems in the field of the designing instrumental aids for the blind. In particular, it has highlighted the interesting problem of the relative advantages and disadvantages of a multipurpose instrument and an instrumental assembly specialized for application to one job.

The replies and discussion with the blind experimenters suggests that major interest in the multipurpose aid has been in its use as a light probe. Nevertheless, the author believes that in a revised design of the instrument the possibilities for versatility should be retained with due regard to the expressed wish for a pocket-light probe which has instant usability as such.

RECOMMENDATIONS FOR MODIFICATIONS IN DESIGN

In making the following recommendations I have in mind an instrument that has both the flexibility and versatility required by science students doing practical work and facilities for instant general usage.

Oscillator

The only modification called for here is an increase in voltage of the dry cell battery to 3 V and the incorporation of the modification in circuitry given in Figure 6. This should satisfy the demand for a signal audible at a distance.

Oscillator Housing

I suggest for this a rectangular box, external dimensions 1-1/2 x 1-1/2 x 5/8 in. It should be furnished with two jack sockets, one at each of the opposite small faces,

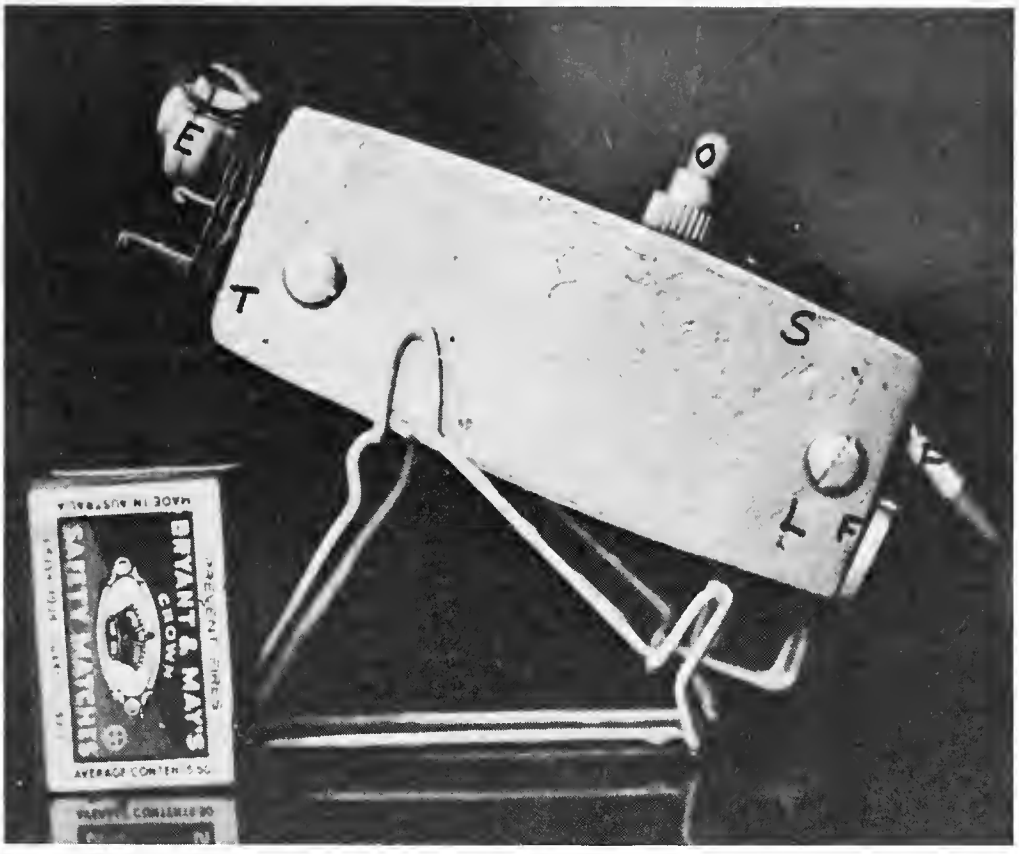

Figure 6. Modified Oscillator

and one good quality switch. The case also should be fitted with two spring clips, one to fix the tube containing the photocell, and one to fix the earpiece in position.

Light Probe

The photocell (Photronic SP5-3) should be securely fixed inside a light plastic tube, the total length (including the tapered aperture) not to exceed the length of the case. The cell can be connected to the oscillator, with a short length (say, 12 in.) of twin flex, terminating in a jack plug. The spring clip that holds the tube containing the photocell (the light probe) should be fixed to the rectangular case of the instrument in such a manner that the light probe is normally carried ready for use—that is, on the outside of the case and parallel to its long axis.

The provision of alternative phototube apertures was one feature of the equipment that received favorable comment. If it is decided to retain this feature, the nozzles should be provided as fittings that screw into the inside of the photocell tube.

Earpiece

The earpiece should be provided with a short length of twin flex terminating in a jack plug. The spring clip for holding the earpiece should be on one of the small faces of the rectangular box. The earpiece would normally be used in this fixed position. Under noisy conditions, or for persons with defective hearing, it can be worn at the ear.

Connecting Other Accessories to Oscillator

To enable the oscillator to be used for purposes other than with the light probe the equipment should include a short length of twin flex terminated at one end with a jack socket and at the other end with two small alligator spring clips for making the circuit with the accessories. The alligator connectors should be insulated on the outside to avoid shorting should they touch each other.

Illumination with Color Filters

In view of the considerations mentioned above and in the interest of low production cost, special illumination where required for color work should be obtained by using a separate ready-made torch, rather than incorporating a lamp into the oscillator unit. It is a simple matter, alternatively, to design a fitting whereby the photocell tube can be fixed at the appropriate angle to a ready-made torch which can be held in the hand during use. This arrangement would be equivalent in function to light probes that have been made with built-in lamps. But it would have the additional advantage of leaving the oscillator available for very many uses not requiring the light probe. It also would permit employment of the light probe where it is advantageous to be able to use the photocell at a distance from the oscillator.

THE FUTURE OF THE PROJECT

The author, naturally, was encouraged by the fact that this eminent group of blind citizens unanimously agreed that an instrumental aid of the type submitted should be made more readily available to the blind community. The question now is,"Where do we go from there?"

This is not exactly a $64,000 question, in the sense that there are prospects for enormous profits for a manufacturer. The instrument could be made for about £ 5, which is below the limiting price of twenty dollars set by Professor Benham in the qualification to his reply to this question.

Over the past six years, and so far without success, I have repeatedly tried to persuade manufacturers of electronic apparatus to engage in the large-scale production

of the device. This failure resulted from inability to obtain a reliable estimate of the demand for such a device. Valuable as the field trial has been in many respects, it has not answered this question. Such information is needed to engage the interest of a manufacturer in the project. What further steps might be taken to get this information? Some guidance can be gained from the consideration of the following very interesting problem.

What in general are the factors that determine the fate of projects for instrumental aids for the blind?

Some empirical data bearing on this problem can be derived from the comprehensive *Catalog Appendix* compiled by Leslie L. Clark as Volume IV of the *Proceedings of the International Congress on Technology and Blindness* (New York: American Foundation for the Blind, 1963).

Equipment cited in this catalog falls into two distinct classes: *(1)* listed as "not available" and generally described as "experimental prototypes" (there are 221 examples of such entries), and *(2)* listed as "available" and with sources and prices given. Items listed as unavailable include:

Electronic blind guidance devices
Electronic reading machines
Phonetic typewriters
Science apparatus
Electronics engineering apparatus
Optical probes
Tape recording accessories
Punched card readers

The Kay Ultrasonic device, listed in 1963 as "experimental prototype," is now available for £70.

Many of the unavailable devices have certain features in common.

1. They are very expensive.

2. They require instruction and long periods of learning to use.

3. They are not in great demand because most blind people can manage without them.

4. Most are complex and highly sophisticated electronic devices.

Devices listed as available include:

Miscellaneous equipment for school for the blind	150+
General household aids	20
Needlework aids	7
Walking canes (not including electronic cases)	23
Clocks and watches	47
Games, toys, and puzzles	79
Miscellaneous tools for crafts	51
Medical syringes (insulin)	5
Talking book and tape recorders	8

Features common to this class include:

1. Low price associated with simplicity of construction.

2. General utility, hence great demand.

3. Many can be classed as "brailled" versions of existing mass-produced commercial articles—for example, clocks and watches, household thermometers, and barometers.

4. Most are marketed by institutions for the blind.

5. Successful usage does not require long learning effort.

The total quantities actually consumed are not known, albeit knowable.

The main feature to emerge from this survey, and it has direct bearing on our present problem, is the marked predominance of school equipment in the catalog. There are obvious reasons for this. The quantity of material aids produced for schools of the blind may well exceed that of the sum total of all the rest. Hence to promote the device we are discussing from group 1 into group 2, and make it available at a reasonable price, we should further its introduction into the schools, where indeed it has already achieved a minor entry (minor in the sense that the number of schools using it is small and in each there might be not more than one).

As a final recommendation, therefore, I suggest another small-scale trial, but of a somewhat different nature. The implementation of such a trial would require an act of faith in the project on the part of an institution with the means for sponsoring it and also the cooperation of a fairly large school for the blind, preferably a senior school where science is taught. An instrument would be given each blind student in the science class. Students would be thoroughly instructed in the various uses of the device in practical science, and at the same time they could be encouraged to find other more general uses for it. After the lapse of an adequate period the teachers would be in position to judge whether, and if so at what stage, such a device should form part of the standard equipment issued to the blind student.

A trial such as this has certain advantages:

1. Its low cost and ease of organization.

2. If it results in a favorable judgment, there might be a steady demand for the device in the educational field, which would encourage a potential manufacturer to submit tenders for supply.

3. Experience thus gained by teachers and students could lead to further useful suggestions for improvement.

ACKNOWLEDGEMENTS

On page 21 of *Experimental Science for the Blind*, and again in the descriptive pamphlet "Multipurpose Sensory Aid for the Blind" (Appendix 1), it is stated that the electronics in this device was the work of Mr. Ralph Herman.

I had asked Mr. Herman to design a simplified transistor circuit which could be used instead of the thyratron relay which I had previously been using in many of the devices in my science laboratory for the blind students.

He came up with a most elegant solution, which is described in the book, and subsequently with an improved miniaturized version used in the device distributed.

If the device has to be named, then let it be called the Herman Oscillator.

Mr. Aubrey Clark, a blind switchboard operator, is one of the few recipients to use the probe in his daily work.

I include in this report a copy of his most interesting letter, not only because of the valuable suggestions he submits, but because it introduces a human element into the somewhat dry subject matter of this report. (See Appendix 4.)

Thanks are due to the Plessey Company of England, which made this trial possible by supplying the instruments without charge, and in particular those members of the Plessey Research Laboratories at Roke Manor, Hampshire, who participated in the production of the instruments.

For most valuable help in distributing the instruments and collecting the reports I am gratefully indebted to Leslie L. Clark of the American Foundation for the Blind, New York, and to Cedric A. Garland, Technical Officer of the Royal National Institute for the Blind, London.

For valuable assistance in making a modified design thanks are due to Charles McCombie of Melbourne.

Of course the most important contribution to this effort was the work of the blind cooperators in experimenting with and evaluating the instrument.

I was particularly fortunate to have received in this work the services of members of the staff of the Sensory Aids Evaluation and Development Center of the Massachusetts Institute of Technology, of Professor Thomas Benham of Science for the Blind, and J. C. Swail of the National Research Council of Canada, Ottawa.

To these, together with all those who collaborated not only in evaluating the device but in offering valuable suggestions for its improvement, our sincere thanks are offered.

For most helpful assistance in secretarial matters and in reproducing the illustrations, thanks are due to Harold Wexler.

Appendix 1

MULTIPURPOSE SENSORY AID FOR THE BLIND

Descriptive Pamphlet by A. Wexler

The title "Multipurpose Sensory Aid" is chosen hopefully. A limited number of these sensory aids have been made as an experiment for distribution among selected blind people. The present model is similar in principle and function to the instrument described in *Experimental Science for the Blind* (New York and London, Oxford and Pergamon Press, 1961, pp. 96-7) under the title "Audible Light Intensity Indicator" or "Light Probe." The size has been reduced so that the instrument may now be conveniently carried in the pocket.

The original instrument has been used with success for some years by blind students in science laboratories and to a limited extent by blind workers in industry. It is felt that the device could prove of service to blind people in everyday life. To determine whether this is so is the main objective in this present exercise.

It is hoped that the blind recipients will be able to suggest uses that would not occur to the sighted person. The device already has multiple uses. We aim to extend these by providing blind people with further opportunities to explore the potentialities by personal experimentation.

In its present format the device is not engineered for production and therefore is not on the market. For the purpose of these field trials the instrument is offered without charge.

General Description of Performance

In this section I shall try to explain general performance principles in language understandable (I hope) to the nontechnical reader. The concluding section, for recipients who are knowledgeable in electronics, contains detailed technical information of the circuitry and quantitative data of performance. Embossed and brailled diagrams of the circuits have been included for the benefit of blind technicians.

In general terms the device may be described as an audible conductance indicator. Translated into English, this means that it can inform the blind observer, in terms of sound signals, about the electricity-conducting properties of the object connected to the brass terminals of the device.

The main part of the device without the accessories will be called the "oscillator"; it is housed in the small plastic case. For connections there are two screw brass terminals and the earphone jack. Accessories such as the light probe, thermistors, and so forth, which are used connected to the oscillator, will be called "sensors."

To demonstrate the property of the device as a simple conductance indicator try the following. Insert the earphone connection and, wearing the earpiece, move the switch upwards to the "on" position. Under these conditions no sound will be heard in the earphone. Now place a fingertip on each of the brass terminals. You should now be hearing intermittent clicks in the earphone. The frequency of these pulses is a measure of the state of your skin as a conductor of electricity. Now repeat the experiment after moistening the fingertips with the tongue. A much higher note is heard, which indicates that wet skin is a much better conductor than dry skin. This phenomenon, the variation in skin conductance, was the basic observation in the original form of the lie detector. I do not know whether this device could be useful in detecting lies, but in teaching science to the blind it is extremely useful for demonstrating scientific truths.

Here is another simple experiment which illustrates the use of the instrument as a contact probe. Connect the two bared ends of the flexible insulated wire to the brass terminals. Lower the other ends of the wire into a bottle partly filled with water. Contact between the wires and the water will be signaled by a high-pitched note in the phone, thus giving to the blind observer information about the position of the liquid level in the bottle.

With relatively simple modification this contact indicator can be adapted for making precision measurements, numerous applications of which can be found in *Experimental Science for the Blind (op. cit.*. pp. 19 and 20 and Figs. 1, 3, 8, 11, 12, 15, 18, 21, 29, 31). In many of these applications the recommended contact indicator

was the Thyratron relay which I was using when the book was written. For most of these uses the present oscillator can be substituted. It is very much cheaper than the Thyratron device, more convenient to use, and more versatile.

Light Indicator and Light Probe

So far we have been discussing the use of the device for providing bare information, "contact or no contact." Simple as such information is, it is not to be despised, for this "Yes" or "No" type of information bit is the basic principle by which computers operate.

We now proceed to applications that depend upon the important property of the circuit to respond with pulses at frequencies proportional to the conductance of the appliance connected to the oscillator. One of the most useful and interesting applications for the blind observer is as a light intensity indicator. A photoconductive cell, which has the property of extremely small conductance in the dark, but which becomes conductive in proportion to the degree of illumination on the active material of the cell, is used. In the case of the small photocell provided with the oscillator, the photosensitive material is a combination of cadmium sulphide and cadmium selenide. The small photocell is housed on the end of the brass tube which is supplied with two alternative apertures in the form of conical screw-on caps. The larger has an aperture diameter of about 1/10 in., and the smaller, which is recommended for discriminating thin lines, is about 1/16 in. in diameter. Used in conjunction with the oscillator, this photocell is extremely sensitive to light, and for most purposes the ambient lighting of a livingroom is sufficient.

To gain some knowledge of the sensitivity of the instrument to light, the following preliminary experiments are suggested. Connect the probe, fitted with a larger aperture, to the brass terminals and, wearing the earphone, switch to the "on" position. Pointing the probe at random in the room, you should hear a clicking sound in the phone. If you point the probe in the direction of the window in daylight, you may get a high-pitched note (pitch depends upon the brightness of the sky). Alternatively, the high-pitched note can be got by directing the probe to an electric lamp.

With the probe still pointing to a bright light source and giving the high-pitched note, cover the aperture with a fingertip. Now you may hear a slow rate of clicking which indicates that a small amount of light is penetrating the finger to the photocell. This simple observation demonstrates the high degree of sensitivity of the cell because it is difficult under ordinary conditions to see the transparency of the finger by the eye. If the aperture of the probe is covered with metal—for example, a coin—no sound response is obtained because the metal is completely opaque.

You may dare to experiment further with this instrument. For example, if you cover the aperture of the probe with the palm of the hand and point in the direction of a bright light source, you will find certain positions on the palm that transmit some light and others where none comes through because the bones are in the way of the light.

It is clear from these simple observations that the light probe can provide a blind observer with information, which is linked to direct sensory experience, about the materials of his environment, their transparency, the reflectivity of different surfaces, and so forth.

To examine the response of the instrument to different colors, I have included with this equipment a strip provided with adjacent sections in different colors which are named below in braille. Place the strip in a good light—say, near a window in daylight—or under an electric lamp. Rest the probe with the larger of the conical apertures over the strip, but inclined at a slight angle to the vertical. As the probe is moved slowly across the strip, a definite change in tone will be heard when it passes the boundary separating one colored section from the next.

It is proper to emphasize here that the simple light probe used with this procedure is not adequate for positive color identification. Although the particular photocell supplied is more sensitive to red light than to blue, color is only one of the factors that influence the response on probing a surface with the photocell. The sound heard will depend upon the intensity of illumination on the surface tested, the reflectivity of the surface, and very critically upon the conditions controlling the entry of light from the reflecting surface on to the surface of the photocell. The problem is further complicated because colored surfaces come in a very great variety of shades and color combinations.

Obviously, providing the blind observer with an instrumental colorimeter demands more sophisticated equipment and a more elaborate procedure. The RNIB in London has made such a colorimeter. Light from three lamps, which is mechanically fluctuated, is directed on to the sample through a system of color filters, and thence by a lens system to a barrier photocell coupled to headphones. It is claimed that a skilled blind observer can learn to identify the color of surfaces with this apparatus.*

There are, however, special circumstances in which the simple probe could be useful to the blind observer, if not to identify colors as such, at least to distinguish a colored object from one of a different color. It is particularly useful in chemical experiments in which one wishes to observe the change in color which occurs in chemical reactions.

It follows from the previous discussion that equality in sound response from two surfaces cannot be interpreted as indicating identity in color. For example, it is generally possible to find a gray surface that will give a sound response similar to a colored surface. Using transparent color filters with the light probe overcomes some of the difficulties and, within limitations, enables us to obtain more definite information concerning the color of the surface examined.

**For further information concerning this colorimeter apply Royal National Institute for the Blind, Great Portland Street, London W.1.*

A red, a blue, and a green transparent film attached to a short piece of rubber tubing which will fit over the probe aperture are included with this equipment so that the blind experimenter may study use of light filters with the probe. There are brailled identification letters R, G, and B[1] on these accessories.

For this experiment arrange the lighting on the color strip so that the response in the phone is a slow clicking. When the aperture is covered with the red filter it may be found that the sound responses from the white strip and the red section are nearly equal and that no sound is heard from the green, blue, or black section. Similarly, with the green cover filter, nearly equal sounds will be heard from the white and the green sections, but none from the red.

Transparent color filters can be used in various ways—as cover pieces on the probe, as cover strips placed over the surface to be examined, or as color screens over the lamp used for illuminating the surface.

At this stage I cannot recommend any general method for the use of the light probe for color information. My feeling is that it would prove useful to the blind person if applied to special problems—for example, the identification by color of one among a limited range of objects, particularly if a sample is available that has the same colored surface as the one sought.

Such special problems, which might be of some practical interest to the blind person, could be much simpler to solve than the more general problem of the accurate colorimetry of an unknown colored surface. For this, which concerns specialists, more sophisticated equipment and procedure are indicated. It is hoped that this field trial will turn up information about color problems that might be tackled with the simple light probe and color filters.

Pointer Readings

In the first section of the colored strip, above the part labeled "Pointer" in braille, there is a wedge-shaped piece of bright aluminum foil, the sharp end pointing to the right. With the light probe held at a suitable angle, a positive sound signal can be obtained from the sharp end, where the width of the aluminum is about 1/100 of an inch. The probe can pick out such a very thin line because of the high, mirror-like reflectivity of the aluminum.

This example illustrates the use of the light probe for reading the position of thin pointers on instrument scales. We see the advantage of giving the pointer high reflecting power and making the background black. For precision measurements it is advantageous to attach the light probe to a lever which rotates about the same center as the instrument pointer and permits the necessary magnification of the instrument scale. (See *Experimental Science for the Blind, op. cit.*, Fig. 8, p. 58.)

Looking at Shapes

In the three sections at the right end of the color strip the letter L is marked thus: *(1)* in black on white background; *(2)* in white on black background; *(3)* in bright aluminum on black background. The three Ls are raised and can be followed with fingertips, but it is suggested that a trial be made tracing the shapes with the light probe and comparing the effects in each case.

Other Applications of the Oscillator:
For Thermometry

Resistors called thermistors are available; their conductance increases with small changes in temperature. They are made in various ranges. A type suitable for use with the oscillator provided is the Mullard Thermistor V.A. 3716. If such an element is connected to the terminals of the oscillator, a low-pitched note is heard at room temperature, and this rises to a high-pitched note if the tip of the thermistor is warmed in the hand or mouth. This note can be accurately matched with that given out at a certain position on a variable resistor which has been calibrated in degrees F for use as a clinical thermometer.

For Rapid Resistor Identification

This application could interest blind workers in radio or electronics. Resistor values can be identified roughly by the pitch of the note given when connected to the oscillator. More precise determination can be made by matching the tone against that given a calibrated variable rheostat.

Summary of Present Uses

The device has been in use for a number of years in my laboratory which is equipped for blind students of science. It also is being used in various schools for the blind in England and in Japan. In this field it is an extremely versatile instrument. With it the blind student can obtain direct meaningful sensory experience of a variety of phenomena, which is normally dependent on visual perception.

This list of some of the present uses might suggest to the readers other uses.

As contact indicator for

1. Accurate measurement of volumes of liquids;

2. Reading position of pointer on scales of measuring instruments such as ammeters and pressure gauges;

3. Accurate weighing with spring balance;

4. Reading mercury thermometer;

5. Electrical measurements requiring "null point" determination;

6. Use as contact indicator with micrometers.

As light probe for

1. Observing color changes in chemical reactions;

2. Accurate reading of pointer instruments;

3. Making observations in experiments on light, as, for example, the inverse square law of propagation, laws of reflection, refraction, and dispersion of light, locating real images using lenses and concave mirrors;

4. Reading sundials and the more general study of shadow phenomena;

5. Studying the basic principles of photograph—in particular, scanning the shapes of objects photographed and developed by the blind students;

6. Observations with the gold leaf electroscope;

7. Experiments in biology such as the demonstration of photosynthesis.

Details of the practical arrangements for many of these applications may be found in my book *Experimental Science for the Blind.* Further information will be gladly given by

A. Wexler
129 Maud Street, North Balwyn
Melbourne, Australia

Description of the Equipment (Technical)

The equipment provided includes

1. A transistorized blocking oscillator housed in a 3-1/2 x 1-1/4 x 3/4 in. plastic container and fitted with two brass screw terminals and a jack connection for the earpiece.

2. One crystal earpiece.

3. A calcium sulphide-selenide photoconductive cell type SP5 (Photronic Controls Ltd.), fitted as "light probe" into a brass tube provided with two interchangeable conical caps.

4. Spare piece of flex.

5. Colored test strip.

The circuit diagram of the blocking oscillator is enclosed in this pamphlet, together with an embossed diagram on aluminum foil for the benefit of blind readers.

The pulse frequency of the oscillator is proportional to the conductance across the two terminals and is of the order of 130 pulses per second (pps) per micromho.

The current consumption from the 1.5-V battery is proportional to this conductance, and is about 0.1 microamperes (mA) per pps.

The 20,000-ohm resistance limits the maximum frequency to about 6,000 pps. and the current to a maximum of 600 μA.

The minimum conductance across the terminals necessary to produce any pulses is within the range 0.02-0.5 micromhos.

The sound level in the earpiece in the oscillator is adequate for most uses. Increased sound volume, if desired, may be obtained by the additional components connected to the earpiece ends, as illustrated in Fig. 2. This modification is not included in the equipment.

Acknowledgements

This field trial has been made possible by the generous gesture of the Plessey Company of England in whose Research Laboratories at Roke Manor in Hampshire the instruments have been made without charge.

This is a field of endeavor in which aid is freely given by many helpers, too numerous to mention personally. But on this occasion special mention must be made of the most valuable assistance given to me in this work by Mr. Ralph Herman, who made the original bench model in 1959 and subsequently devoted much thought and time to the problem of its miniaturization.

This opportunity should also be taken for acknowledging with thanks the cooperation of those blind workers who have agreed to accept the device and to explore and report upon its usefulness.

Finally, a special word of thanks to Mr. Peter Patel, who constructed these instruments while working as vacation student at the Plessey Laboratories.

Appendix 2

QUESTIONNAIRE

Please strike out the words which do not comply with your opinions and return the form to me with your signature.

1. I have found that the device has been useful to me on many, rare, no occasions.

2. The device in its present form is easy, difficult, impossible for me to use.

3. I would like to retain, return, the device.

4. The following are some of the purposes for which I have found the device particularly useful:

   Locating the sources of light, e.g., windows, lamps, bright surfaces.

   Distinguishing colored objects.

   Determining levels of liquids in containers.

   Identifying the values of resistors.

5. In the light of my personal experience I have formed the opinion that it would, would not, be of value to make this device more readily available to blind people.

Signed _____

Appendix 3

MR. JOHN K. DUPRESS' REPORT

Comments on Wexler Device, General

1. Earphone falls out of ear.
2. Earphone cord tangles.
3. Typist used it to find bottom line of type.
4. Light source should be mounted on probe to eliminate shadow.
5. Used to determine if domestic hall lights were on.
6. Difficult to maintain optimum probe-to-object distance; needs transparent spacer.
7. Used to find stripe on data cards.
8. Music teacher could use device to follow musical staff on blackboard.
9. Subject wants infrared filter so he won't pick up hot objects.
10. Could not distinguish green from red.

Suggestions for Improvement

1. Spacer permanently affixed to probe orifice to maintain optimum probe-to-object distance.
2. Light source affixed to probe body so that shadows do not block light path.
3. Loudspeaker preferable to headphones.
4. If headphone is to be retained, an ear clip is recommended.
5. Probe weight could be reduced by using aluminum or plastic probe body.
6. Filters should be easier to install and be more durable.
7. Threaded earphone member broke, so more durable member should be constructed.

M. I. T. Sensory Aids Staff

Report based on observations of 9 blind people.

Appendix 4

LETTER FROM MR. AUBREY CLARK

63 New Street
Brighton Beach
30th April, 1966

Dear Mr. Wexler,

Contrary to my earlier thinking, I have been rather disappointed in finding that the Electronic Sensitized unit has not to me been as useful that I felt sure it would be. It could be if it were constructed in some other way. In theory it has a wonderful potential as an aid to blind people. The principle of it is excellent. Under experimental conditions its performance is all that could be desired of it.

Then when it comes to putting it into practice in the busy running the gauntlet of this busy work-a-day world the construction prevents it from being put into practical use. I think that instead of it being tossed to a blind person to see what he can do with it, it should be tested for the requirements of each individual, under the supervision of a sighted person, qualified to make modifications to suit his or her own particular requirements. This may not be practicably or economically possible. But, the Department of Social Services, rehabilitation, or a wealthy organization like the R.V.I.B. ought to help out there. If one were working at an undisturbed laboratory bench, or an office desk all day, the present arrangement with its separate component parts would be quite satisfactory. The main cause of trouble that I find lies in the impatience, the lack of interest in other's problems, and the general lack of observation and use of their sight to the full, of sighted people, in whom, unfortunately we have to depend on for certain help, and have to take it immediately it is offered, or, not get it. I suppose one could put this all more concisely by saying that "It is due to human nature, and the tempo of the times."

In my individual case I hoped to find in your unit a portable readily available for instant use indoors, out-of-doors, traveling in a train or in the busy city street. In my first burst of enthusiasm after my first experiment, I wanted to show my associates what I had already found it could do for me. But, when I did, I found that these things came so naturally and easily to sighted people that their attitude was "Why bother," or they were just too impatient that they walked away while I was trying to untangle the lead wires without success and getting them more tangled through trying to rush it. On one such occasion my friend came up to me and said "come on Aub, we are all going into the other room now" and tugged my arm. I said I must gather up all these parts, have I got everything? Just look Jack and see that I haven't dropped anything. "No, you're right Aub, come on." As a result the

two pointed aperture tips were left down in the side of an arm chair. I did not meet our host until a week later when they were returned to me, but in the meantime I had been frantic. I had my wife search our house, I went through every suit pocket about six times, I unwrapped all the parcels of rubbish in our dust bin, I crawled around and searched likely spots in the garden. On the sixth day I asked for a search to be made through the bales of waste paper in the office.

During that week, however, not knowing how fraille the inner construction of the probe was, I had become to depend on it so much, that I went on using the apparatus; the consequence of this, I am very sorry to say, is that the little disc at the business end of the probe has been damaged and it does not seem to either clip or screw back into place. I do hope that it can be repaired. I don't remember a warning about the possibility of this happening being read out to me in the accompanying pamphlet. I found the electrode very helpful in measuring liquids. This problem has been one that has been worrying me all through my blindness. I detest the filthy practise, of dipping the finger into the glass, that some blind people use. Of course, I know, I am fantastically fastidious. But the drawback to the use of the electrode is the tediousness, of changing over and attaching wire to screw on terminals.

Some of the uses that the electrode could be put to.

1. Measuring liquid medicines.

2. Measuring the right amount of milk to put in the bottom of a cup.

3. Measuring liquid ingredients of cooking recipes.

4. Measuring the etiquette amount to put into a cup or glass.

5. Measuring a nobler of whiskey, or a double Scotch.

6. Measuring the ingredients of a cocktail drink.

7. Measuring poisonous liquid concentrate of garden sprays, and pesticides.

8. Indicating when the teapot is filled (this one should have headed the list as No. 1).

It is of my opinion that the electrode is the most important most practical aid to the blind.

Uses of the electronic eye or probe is as far as I have gone. (I mean that my findings are very incomplete at this stage, because of the inconvenient construction and having damaged what seems to be the vital part of the probe.)

1. It is most effective in detecting.

It is most effective in detecting lamp signals on a telephone switchboard.

Quite good for locating the position of the lamp in a room and saves waving a walking stick around when one wishes to find where it is to place a chair under it to change a dead globe. This saves a lot of damage and loss of ornaments and vases of flowers.

It does NOT, as I had hoped it would, indicate approaching car headlamps.

Nor does it indicate position of street lamps.

Nor does it seem to respond to indirect lighting, or the light that comes through an open doorway or a lighted room into a darkened room.

Of course finding the position of the window in a room in daylight is extremely important to a blind person.

It does not indicate, as I thought it would, the difference coming through a railway carriage window when the train emerges from a tunnel; this amazes me as I remember from when I had sight quite a bright light came through a train window.

Constructive Criticism

An unqualified person's suggestions for improved construction.

1. That all wires should be eliminated.

2. That all appendages should be incorporated in the body of the unit itself.

   (a) That the ear phone should be attached to a telescopic tube that could be pulled out from the top of the unit where the present E.P. plugs in.

   (b) Likewise the electrode could be a thick telescopic rod from one side of the lower end of the unit, or a hinged rod clipped on to the side of the case.

   (c) That the electronic eye or probe be enclosed in the lower end of the unit and that the conical apertures be made to screw into a shallow orifice. I wish I could draw a diagram to illustrate.

I think that if the earphone shaft were made to extend to about twelve inches and were of some highly flexible metal, that would be quite long enough. I have a pocket transistor radio which has a telescopic tube aerial. This one came out of a case 3 inches wide and extends for 18 inches I find on examining it while typing this.

On the other hand if we have to have wire leads, why not have them to plug in like the ear phone does. For my individual case could I have those leads made of thicker wire like the spiral cord on a telephone, and could they be shortened to about a maximum of 16 inches.

I think I could receive a lot of help if I could have a face to face interview (in French, "Tete a Tete" or "Viz a Viz").

I believe we have a mutual friend in Mr. Eric Lake, who lives just near to me. We may be able to arrange something, that is, if you were agreeable. Oh, the reason for trying to get away from the ear plug stuck in the ear is that when working with a telephonist's headphone over one ear and that one stuck in the other, one is prevented from hearing little sounds which a blind person needs so much to identify.

Well, it is after midnight, so I shall say "Goodbye, until next time" (Dr. Floyd).

Yours faithfully,

Aubrey Clarke.

THE PHYSICALLY HANDICAPPED IN DENMARK

Editor's Note:

The following report is a collation of the English summaries to the four volumes of the study of the physically handicapped in Denmark. This project was undertaken by the Danish National Institute of Social Research in 1961 and ended in 1966. For the convenience of the English reader, the tables relevant to the English summary text are provided. Permission to reprint the English version was granted by the courtesy of the Danish National Institute of Social Research, and by its Director, Dr. Henning J. Friis.

The study is offered to our readers as a model for a national study of all forms of physical impairment, and to aid in the exchange of national data having relevance to cross-cultural comparisons. For details on the data reported in the tables, we refer the reader to the original Danish text.

I. The Techniques and Methods of the Study

During the last twenty years there has been a growing interest in rehabilitation in Denmark. In this country the concept of rehabilitation is not confined to a series of measures or techniques aimed at normalizing the occupational situation of physically and mentally handicapped persons. Rehabilitation is thought of as an objective which should, to a large extent, influence the general social policy of the state. Thus rehabilitation measures include not only individual physical, mental and occupational therapeutic techniques, but also adjustment of the social milieu of the handicapped (that is, treatment of the whole family, adjustment of cash benefits and social services for the purpose of rehabilitation, creation of state rehabilitation agencies promoting the coordination of rehabilitation measures, and so forth).

This concept of rehabilitation raises many problems, the solution of which is a task for social research.

In 1958, the organizations for combating disease, the organizations of disabled persons, and the Danish Organization of Cripples offered to support the Danish National Institute of Social Research if it carried out a survey of handicapped persons in Denmark. After a preliminary pilot study, the institute undertook a nation-wide representative survey covering 10,000 households. From April, 1962, until November, 1963, the data were analyzed by doctors attached to the project. Results have been published in four volumes: *I. The Techniques and Methods of the Study; II. Some Major Results of the Study; III. Housing Conditions and Transport Problems;* and *IV. Work and Employment.*

THE OBJECT OF THE STUDY

The object of this study is to give a sufficiently reliable picture of the number of physically handicapped persons as well as their distribution by diagnostic groups, sex, age, education and training, occupation, income, housing conditions, and so on. Furthermore, the study seeks to collect information concerning the effectiveness of existing social services for these persons and about their need for further measures, with special reference to rehabilitation.

The broadly formulated aim falls into two parts: First, we wish to obtain, through a frequency survey, an estimate of the number of the physically handicapped and their distribution in different groups. This will give an idea of the magnitude of the problems and thus provide a basis for estimating the optimal capacity of rehabilitation services. Moreover, this frequency survey will contribute to a picture of the general conditions of handicapped persons, particularly with regard to income, housing, and occupation.

Second, it is hoped that the study will provide a reliable basis for considering how rehabilitation services should, concretely, be made available to physically handicapped persons.

We know that there are considerable differences in the extent to which physically handicapped persons at present manage to overcome the negative effects of their handicap. It is part of the object of the study to illuminate the factors causing some persons to manage well, in contrast to others who do not succeed in overcoming their handicap.

SAMPLE DESIGN

To ensure that this is a representative survey, it is important that the study should not cover only handicapped persons who are already in contact with medical practitioners or social service authorities. This would mean that only a few people who have managed to overcome the effects of their physical handicap would be included, and the basis of the analysis would be biased. We therefore rejected the obvious idea of tracing handicapped persons through practitioners' records. Instead, we attempted to locate all handicapped persons in a representative stratified random sample of 10,000 households through special interviews on health conditions.

DEFINITION OF PHYSICALLY HANDICAPPED PERSONS

An attempt to formulate a theoretical and practical definition of the physically handicapped is made difficult because it is often impossible to clarify the causal relation between physical handicaps and difficulties in coping with situations arising from the problems of daily life.

As mentioned above, it is an essential part of the aim of the study to throw light on the nature of this relationship. This goal can be realized only if the survey includes both persons who experience difficulties in connection with physical diseases and defects, and persons who have wholly or partly compensated for the effects of their handicap.

Hence we decided that only the nature and degree of the physical handicaps should be decisive in selecting those to be included in the survey. We took our point of departure in the following definition of a physical handicap:

> *For the purposes of this survey a physical handicap is defined as a protracted physical disease or defect of such a degree that an unskilled, unmarried worker without support from his surroundings and with mental reserves and energy a little below average, normally would have difficulty in coping with daily life on an equal footing with others if he were suffering from the disease or defect in question.*

In other words, the difficulties caused by the physical handicap need not actually be present for a person to be included in the survey, if they have been compensated by, for example, favorable social circumstances, particularly high intelligence, or great energy.

Beyond this, it has been found expedient to limit the survey to persons between the ages of fifteen and sixty-one, because we wish to emphasize the description and analysis of employment conditions.

This somewhat abstract and cumbersome definition was put into practice through a special process of selective interviewing combined with a final check by doctors on the basis of specified criteria.

DESIGN OF ANALYSIS AND QUESTIONNAIRE

Tracing the Physically Handicapped

Interviewers determined whether the households selected included handicapped persons. After collecting information on the composition of the households and certain basic data for the individual persons, the interviewers asked a number of questions about the health of household members. They tried to ascertain whether members were suffering from physical diseases or defects, whether they had been ill within the past six months, and whether they had been in a hospital within the past three years. Moreover, the person interviewed was handed a list of diseases and symptoms that will generally reveal such diseases not mentioned in the course of the preliminary questioning; the interviewee was asked whether anybody in the household had the symptoms. Those

whose replies indicated that they suffered from diseases and defects—regardless of the nature and degree of these diseases and defects—were interviewed to obtain details concerning the disease and general state of health. If this interview indicated that the diseases or defects could possibly constitute handicaps, as defined for the purposes of the survey, a further personal interview was taken to obtain a description of the course of the disease, admissions to hospital, medical treatment, operations, and so forth. On that basis the interviewer decided whether the interviewee should be considered handicapped.

To help the interviewer make the right decision, a list of symptoms had been worked out. The occurrence of some of these symptoms required that the person be regarded as handicapped. Diabetes, for example, is considered physically handicapping in all cases where frequent insulin shocks, reduced eyesight, or neuritis occur. Difficulty of walking is absolutely handicapping if the person uses crutches or a wheelchair. This does not mean that a person with walking difficulties is *only* regarded as physically handicapped when he needs crutches or a wheelchair.

If these so-called handicap symptoms did not occur, the interviewer was to judge whether the diseases or defects were of such a nature and degree that they would cause the "model person" (unskilled laborer without support or mental reserves) to have considerable difficulties in coping with life on an equal footing with others. Because this procedure gave the interviewer much influence upon the results of the study, the interviewers were carefully selected and intensively trained. Furthermore, the lists of handicap symptoms reduced the number of cases that depended on the interviewer's subjective judgment. When in doubt, the interviewer would always conduct the full interview as if the person in question were physically handicapped.

The interviewer's decisions were checked by physicians attached to the survey. The data on diseases and defects obtained by the interviewers were further supplemented by information from the interviewees' own doctors and from hospitals or other health institutions that had had contact with the handicapped persons. This supplementary information has been of the greatest value in the final delimitation of the handicapped persons in the representative sample.

The survey doctors, thus, make the ultimate decision as to which people are to be considered handicapped, taking all information into account.

Indications of How Handicapped Persons Manage Occupationally

Physical Disablement and Degree of Disablement

On the basis of all available health information the physicians make an assessment of the working capacity of the physically handicapped persons. This assessment is, in principle, made on a purely somatic basis, the doctor's task being solely to judge

how the disease affects the working capacity, whereas the handicapped person's mental characteristics and social circumstances are left out of consideration (this judgment is a natural continuation of the decision concerning whether the person in question is handicapped). The object of this is to divide the handicapped persons into groups that are homogeneous in regard to the occupational effects of the physical defects alone.

The doctor starts by estimating whether the person in question can be considered "not occupationally disabled," "occupationally disabled," or "physically incapable of work." This assessment is made by the doctor without previous knowledge of the handicapped person's present occupational status.

The greater part of the physically handicapped fall into the second group of "occupationally disabled." For these persons a further medical assessment is made, which is divided into two parts:

First, it is assessed whether part-time work is necessary, desirable, or not important.

Second, an assessment is made of the conditions under which the handicapped person can undertake full-time and part-time work. This assessment consists of a statement concerning the types of work that the person examined is able to perform. In practice this is done by checking the appropriate boxes in a schedule. It is possible to indicate whether the work is to be sedentary, indoors, relatively light, and so on. It must be emphasized that the boxes in the schedule are not alternatives. Accordingly, several boxes may be checked. This makes it possible to describe 383 different combinations of work requirements, apart from special measures on the part of the employers and work in sheltered workshops.

An assessment is made of the conditions under which full-time work can be undertaken and of the conditions under which the person examined can undertake part-time work. Under each of these headings there are two subheadings: "necessary" (employment) and "desirable" (welfare). The first of these subheadings is the more important, because here those conditions are checked off that must be fulfilled if the handicapped person is to be able to undertake any work for pay. Under the other subheading the conditions are checked off that must be fulfilled if the person examined is to avoid being exhausted by the work.

This schedule makes it possible to distribute the handicapped persons in the survey into a total of 383 different groups, which are fairly uniform as regards the extent to which the disease or defect affects working capacity. Each of these groups forms an independent description of the physical disablement of the person concerned. This description would be too general if it were to be used as a basis for therapeutic measures. But this is not intended. On the contrary, it is to be used as a basis for further statistical analysis of the relationship between the degree of physical disablement and occupational adjustment.

		Full-time Employment		Part-time Employment	
		Necessary (Employment)	Desirable (Welfare)	Necessary (Employment)	Desirable (Welfare)
a.	Only work in sheltered workshops	☐	☐	☐	☐
b.	Only sedentary work	☐	☐	☐	☐
c.	Mainly sedentary work	☐	☐	☐	☐
d.	Only work indoors	☐	☐	☐	☐
e.	Only work permitting breaks	☐	☐	☐	☐
f.	Only work with limited number of operations	☐	☐	☐	☐
g.	Only work not requiring the use of both hands	☐	☐	☐	☐
h.	Only work not requiring the lifting of heavy loads	☐	☐	☐	☐
i.	Only light work	☐	☐	☐	☐
j.	Only work not involving dangerous machinery or dangerous working conditions	☐	☐	☐	☐
k.	Requires positive, not extensive, measures on the part of the enterprise*	☐	☐	☐	☐

*Specify:

Avoid noise	☐
Avoid work requiring frequent verbal contact	☐
Avoid dust	☐
Avoid dirty work	☐
Must be able to be absent periodically	☐
Other: _____	☐

_____

It is very awkward, however, to operate statistically with 383 qualitatively defined groups. It would be of considerable advantage to the analysis were it possible to weight these groups in proportion to each other so that they could be arranged according to the extent to which the combination of requirements actually reduces the capacity for work.

Such a weighting is attempted, based on the following postulates:

The greater the demand for work of the limited type that the handicapped person can undertake, the easier it is to find work for the handicapped in question.

The greater the number of persons who can only undertake work that satisfies the special requirements, the greater the difficulty in finding employment for the handicapped in question.

On the basis of these two rules a simple expression for the degree of physical disablement has been constructed. For each possible combination of work requirements, we divide the number of places of work that actually satisfy the combination in question. We then get a figure that if it is very low, indicates that there are many jobs compared to the number of handicapped persons. If the figure is high, it indicates that there are many handicapped persons compared to the number of jobs. This figure can, in principle, be calculated for each of the possible descriptions of physical disablement.

The problem is therefore merely to find a practicable method of determining the numerator and denominator of the fraction for each of the combination groups.

The numerator of the fraction is given in the survey as the number of handicapped persons in each of the combination groups. The denominator, however, must be found in another way.

Fortunately, the handicapped persons were traced through visits to a representative sample of Danish households, whether these households included handicapped persons or not. It was therefore possible to ascertain—for the same sample as the handicapped persons had been selected from—the occupations of all gainfully occupied persons, handicapped as well as nonhandicapped. To this end the questionnaire contained questions designed to describe the work functions of the gainfully occupied persons. These questions corresponded closely to the disablement groups by which the doctor classified the handicapped persons. However, the aim here was not a description of the conditions under which the persons concerned could undertake work, but a description of the requirements actually satisfied by their work. Thus the interviewer asked how many hours they worked per week, whether the work was sedentary, whether it was performed indoors, whether small breaks could be taken during the day, whether it was physically strenuous, and so forth. This enabled us to classify into groups by type of work, corresponding to the groups for physical disablement, all gainfully occupied persons in the sample.

For each of these combination groups we are now able to construct a fraction reflecting the degree of disablement of the group in question. Thereby a degree of disablement has also been attached to each of the handicapped persons.*

Measuring the Connection Between Degree of and Adjustment to Disablement

It must be assumed that there is a certain correlation between the degree of disablement of the handicapped persons and their occupational adjustment, and it is important to ascertain the nature of this correlation. Occupational adjustment can be measured in various ways. For instance, the earned income will be an immediately available expression of the extent to which the handicapped person has succeeded in adjusting himself occupationally.

It is to be expected that earned income is a function of a number of different factors, among others, of the degree of physical disablement. If there is a correlation between earned income and degree of physical disablement, it must be a decreasing function.

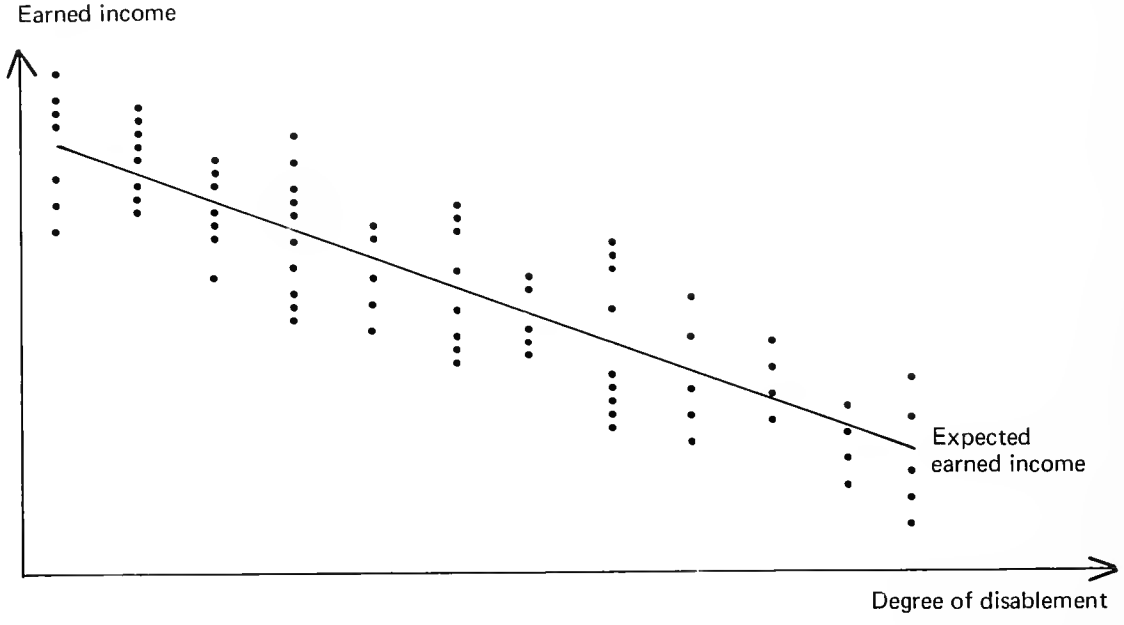

Figure 1. The Physically Handicapped Distributed by Degree of Disablement and Earned Income

**In practice the calculation is a little more complicated than indicated above, because it has to take into consideration the fact that handicapped persons who require, for example, sedentary work will apply for jobs not only fulfilling this condition, but also for jobs fulfilling further conditions, and thus take up places required by more severely handicapped, needing, for example, sedentary plus indoors work. Formulas have been worked out taking this complication into consideration.*

Figure 1 is an attempt to illustrate the hypothesized functional relation between degree of disablement and earned income. Degree of disablement has been plotted along the abscissa, and earned income has been plotted along the ordinate. Each dot in the graph indicates a physically handicapped person and the location of the dot is determined by the degree of disability and earned income. The dots are distributed in a cluster around a decreasing curve (which need not be a straight line). This decreasing curve indicates the functional relation between the two variables. Under the assumptions made, the deviation of the individual dot from the curve accordingly indicates the extent to which factors other than degree of disability have made it possible for the handicapped person to compensate for the effects of the handicap. A dot above the line thus indicates a handicapped person with positive compensation, while a dot below the line means that besides the physical handicap there must be other negative factors which cause the earned income to be below the average for the degree of disablement in question. *The distance between the individual dots and the line is called the degree of compensation.*

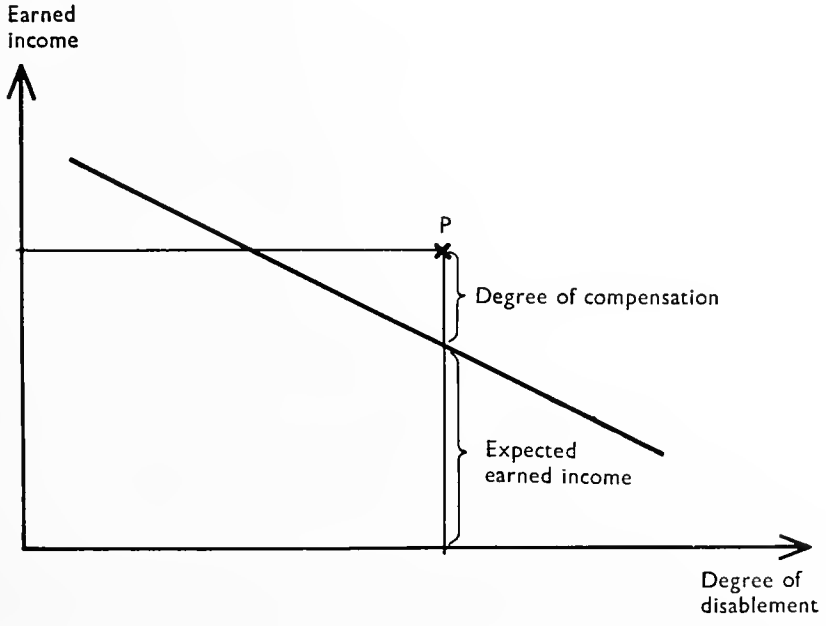

Figure 2. The Relation Between Earned Income, Degree of Disablement, and Degree of Compensation

In the foregoing, earned income has been used as an indication of how people manage occupationally. Other indications might be mentioned, such as occupational welfare, and, moreover, an indication for the degree of compensation for persons outside the labor force has been worked out.

Methods of Analysis and Content of Questionnaire

The analysis of the results received will, as far as occupational conditions are concerned, aim in particular at ascertaining the real contents of the above functions. To begin with, an attempt will be made to ascertain to what extent occupational adjustment is influenced by physical disablement. (First, it is, for instance, desired to determine the nature of and the parameters in the functional relationship between expected income and degree of disablement.)

The functions thus calculated will be regarded as a reflection of how the physical handicap affects adjustment.

It is of at least equal importance to examine the degree of compensation. The numerical value assigned to the individual handicapped person through this function is taken as a quantitative expression of the extent to which the handicapped person has succeeded in compensating for the effects of the physical disease or defect. By examining what factors are correlated with these numerical quantities we hope to be able to test hypotheses concerning causal relations between these factors and the ability of a handicapped person to cope with daily life. The quantities correlated with the degree of compensation may thus be indicators of the factors that determine how a person with a given physical handicap gets along with regard to his work, and thus they may be factors to which rehabilitation measures might be applied. We, therefore, have attempted to derive a series of hypotheses concerning the conditions affecting a handicapped person's ability to cope with his daily life (occupation and daily activities). These conditions, consequently, are included in the survey:

Variables That Are Assumed to Affect a Handicapped Person's Ability to Cope With Normal Existence

Age
Marital status and family situation
Residence (district category, urban or rural district)
Social background
Previous occupation
Wealth
Education
Measures initiated
Transport facilities
What the handicapped person thinks his surroundings expect from him
The attitude of his near relatives
The doctor's instructions as to how much the handicapped person should undertake
Contact with other people
Personality (intelligence, character, attitudes, and mental handicaps)

The concrete needs of handicapped persons for rehabilitation measures are not ascertained by field studies of the individual persons.

Instead we shall attempt, through processing the material, to get a general impression of the total need for rehabilitation measures. The basis for this is the argument that a person needs rehabilitation measures if his handicap causes difficulties that have not been countered or compensated for.

Hence it follows that needs for rehabilitation measures can be ascertained by comparing the requirements that must be satisfied for a handicapped person to be able to perform work for pay with the conditions offered by his actual job.

By means of such comparisons it will be possible to achieve a distribution of the handicapped by their need for rehabilitation. It will thus be possible to divide them into persons having no need of rehabilitation because they are able to work more than they have done previously, persons having a need of rehabilitation because their present work is injurious to their health, and certain combination groups. On the basis of the other data it will be possible to distinguish special groups which might have a need of rehabilitation, but whose need, perhaps, is not otherwise very great, such as, for instance, women supported by their husbands.

To supplement this information the doctors make an assessment of the extent to which medical treatment may be able to bring about an improvement in working capacity.

II. Some Major Results of the Study

Chapter 1 deals with the material and with the distribution of the physically handicapped by geographical criteria.

Interviewers visited 10,377 households; in 1,743, or 17 percent, the interviewing was not carried through because of nonresponse (absence, refusal, and the like). In the remaining households there lived 18,803 persons, who were above 14 years of age at the date of the survey, January 1, 1962. Of these, 15,633 fell within the age limits used in the study, 15 to 61 years. In order to correct some distortions in the material, caused by certain variation in the sample percentage and the rate of nonresponse, 2,830 of these persons have been counted twice. The material then is treated as consisting of 18,463 persons in the age group 15 to 61 inclusive.

To what degree is the sample representative of the total Danish population in the age groups mentioned? This was determined by a comparison with the official Danish population statistics with regard to certain basic criteria such as age, sex,

occupation, and so on (see Fig. 1 and Tables 1, 2, 3, and 4). There are certain minor differences in the age distribution, especially in the 20 to 24 age group, which can be ascribed to differences in definition of population (the official statistics, of course, include, for instance, the military personnel, which the sample does not) and to the difficulties the interviewers had in getting all lodgers registered. For the other age groups and for the distributions by sex, occupation, urbanization, and geographical district the sample is in accordance with the official statistics. It is concluded that the sample is sufficiently representative for the Danish population above 14 and less than 62 years old.

As Table 5 indicates, 1,079 persons, or 5.9 percent of all the persons in the sample, were without doubt physically handicapped. If one includes the group "probably physically handicapped"—that is, persons who are deemed "physically handicapped" on the basis of not quite sufficient medical information—the total percentage is 6.5. The frequency of physically handicapped is about the same for men and women. The percentage of 6.5 corresponds to a total number of about 176,000 handicapped persons in Denmark in the age group 15 to 61, outside the collective households.

Unavoidably, the information about medical, social, and psychological factors is more or less incomplete for some persons; in certain cases there were difficulties during interviewing or in getting information from doctors and hospitals. Consequently, it has been necessary to work with the following groups of physically handicapped. (See Table 7.) The A group includes everybody clearly or probably physically handicapped. Excluding from this group the persons for whom the medical information is incomplete, one gets as the remainder the B group. Excluding also persons about whom there is insufficient social and psychological information, there remains the C group.

The distribution of the physically handicapped by degree of urbanization is shown in Table 8.

The distribution of the handicapped by geographical districts is presented in Table 9. After corrections for the differences in the age distribution, it is found that the physically handicapped are overrepresented in the capital, but to a somewhat similar degree are underrepresented on the rest of the island Sealand, including the suburbs of the capital.

Chapter 2 describes the distribution of the physically handicapped on the basis of diagnosis and type of physical disablement.

For certain groups of illnesses (blind and nearsighted, deaf and hard of hearing, cerebral palsy, disseminated sclerosis, tuberculosis, arthritis, poliomyelitis, and epilepsy) the total number in Denmark is estimated on the basis of the sample as well as on other available information. The estimated number of these special groups of physically handicapped are (age group 15 to 61):

Blind and shortsighted	4,400
Deaf and hard of hearing	6,000
Cerebral palsy	1,800
Disseminated sclerosis	2,300
Arthritis	22,000
Poliomyelitis	3,700
Epilepsy	6,000

As to the distribution of the handicapped by type of physical disablement, it should be mentioned that those persons who were suffering from several handicaps are counted in several groups of disablement. The enumerated approximate numbers of handicapped in the different main groups are difficulties in walking–45,000 (19,000 men and 26,000 women); back insufficiency–47,000 (26,000 men and 21,000 women); other motorial disorders–31,000 (11,000 and 20,000); disorders in sensory functions–15,000 (8,000 and 7,000); disorders in heart and respiratory system–47,000 (24,000 and 23,000); gastrointestinal disorders–12,000 (7,000 and 5,000); diseases of the urogenital system–7,000 (2,000 and 5,000); diabetes and metabolic disorders–16,000 (3,000 and 13,000); other handicaps–15,000 (7,000 men and 8,000 women).

Chapter 3 contains an analysis of age distribution and marital status.

Figure 2 shows the age distribution of the sample; as mentioned above, this distribution resembles the age distribution for the entire Danish population fairly closely.

The age distribution of the physically handicapped is shown in Figure 3. It will be seen that this distribution is significantly different from the age distribution for the whole sample, because of the extremely high frequency of older persons among the physically handicapped. The number of handicapped as a percentage of all persons in each age group are shown in Figures 4 and 5. The percentage is very small for the lower age groups (for the 15 to 19 group the number is 1.6 percent for the men and 1.1 percent for the women), and then grows larger with increasing age, accelerating increasingly from around the fiftieth year of age. For the highest age group in the study (60 to 61), 26.5 percent of the men and 24 percent of the women are physically handicapped.

The marital status of the handicapped and of the total sample is compared in Table 14. The small differences can all be explained by the differences in age distribution mentioned above; the distribution of the handicapped by marital status is thus very similar to the conditions for the Danish population in general.

Chapter 4 deals with the incomes and sources of income of the physically handicapped.

The concept of income that is used is the total income as known by the tax authorities. This information was available for 922 physically handicapped persons.

For the year 1961 the average income was (Table 16) 15,400 Danish kroner for handicapped men and 14,500 D.kr. for handicapped women; as the table shows, there is, however, a wide disparity.

There are no statistics on the incomes of the entire Danish population that are comparable to these figures. A study for Copenhagen for 1961 shows an average income of about 19,400 D.kr. The average income for physically handicapped in the capital calculated in this study is 15,800 D.kr. There are substantial differences between physically handicapped and other people with respect to the distribution of income. Among the physically handicapped there are relatively high frequencies in the income groups below 1,000 D.kr. per year, 7,000 to 10,000 D.kr. per year (disablement pensions), and above 16,000 D.kr. This means that there is a bigger variation in the income distribution of the physically handicapped than in the whole population.

In order to get information about sources of income, interviewers were asked about their employment conditions; the answers are shown in Table 17, separately for the total sample and the handicapped. It is remarkable that four fifths of the handicapped men are gainfully employed. Although this proportion is somewhat lower than the corresponding proportion for the total population, it shows that, as a rule, the main income source of the physically handicapped men is gainful employment. For the physically handicapped women the percentage is considerably lower; but still more than one fourth of them are gainfully employed. The rate of unemployment is insignificant.

In Table 18 the total sample and the physically handicapped are distributed by occupation. For physically handicapped men the proportions of pensioners and self-employed are larger, and the proportion of salaried employees and skilled workers smaller than in the total sample. Where the women are concerned, the proportion of housewives among the handicapped corresponds closely to the proportion in the total sample.

Chapter 5 gives, for persons gainfully employed, a description of the character of employment and of the occupational effects of the physical disablement.

Gainful employment is the main source of income for 79 percent of the males and 33 percent of the females (one third of these women are housewives working together with their husbands in their own enterprise, for example, farm or shop). Disability pensions and other social benefits or employment of spouse are the main sources of income for the remaining.

Most of those who are gainfully employed work all year round, except for short periods of sickness and so forth. Almost all of the men who are working are employed full time (42 hours or more), which also applies to four fifths of the women.

Table 25 shows whether the physical disablement has had any effect on work. Eleven percent of the males and 25 percent of the women have either changed their occupation or their working functions or they have reduced their working time.

From Table 26 it is further seen that 65 percent of the males and 58 percent of the females think their working capacity in the actual job is reduced, and it is further demonstrated (in Table 27) that 31 percent of the males and 23 percent of the females believe that their physical diseases or defects have reduced their possibilities for promotion or obtaining better jobs.

These effects illustrate that only for 24 percent of the men and 30 percent of the women have physical disablements had no effects at all on employment.

Chapter 6 deals with those physically handicapped who are not gainfully employed—19 percent of all the physically handicapped males and 63 percent of the females. Nine percent of the unemployed physically handicapped males have never worked gainfully. Ninety percent of the remaining ceased work because of physical handicap. The corresponding figures for females are 25 percent have never worked gainfully and 44 percent ceased work because of physical handicap.

Most unemployed handicapped persons do not think they are able to work at all. Only 12 percent of the males and 5 percent of the females think they are able to work full time, whereas 7 percent of the males and 8 percent of the females think they can work part time.

Most unemployed women are working as housewives. A majority do all the cooking, cleaning, and washing in their household.

Only a small fraction of the men do anything in the household except prepare small meals and wash dishes.

Thirty percent of the physically handicapped men and 33 percent of the women receive some social benefits. The percentages are considerably lower for the gainfully employed than for the others (viz. Table 34). Disability pensions are the most frequent benefits. Twenty-seven percent of all the physically handicapped receive disability pensions.

If we consider only those without gainful employment, 74 percent of the men and 40 percent of the women are recipients of disability pensions.

Chapter 7 deals with the housing conditions and transport problems of the handicapped.

In Table 39 the physically handicapped have been distributed by the position of their flats (ground floor, first floor, and so on) and the group of handicap. Of the 277 persons suffering from difficulties in walking, 75, or 27 percent, live out of level with the main entrance of the house (in cellar, on first floor, second floor, and so on) without a lift. Twenty-six persons, or nearly one in ten, live on the third floor or higher without a lift. For persons with back insufficiency, other motorial disorders, and disorders of the heart and respiratory system, 26, 29, and 26 percent, respectively, live in flats above street level and without a lift.

Forty-one percent of the physically handicapped live in flats with bath, 80 percent in flats with water closet, and 42 percent in flats with central heating. In all these respects the conditions of the physically handicapped are significantly less satisfying than for the Danish population in general.

As far as transport problems are concerned, it is demonstrated that 9 persons, or 1 percent of the handicapped, were using a wheelchair. Ten persons thought they needed one; of these, four were not living at front door level and did not have access to a lift—one on the third floor.

The problems of outdoor transport are illustrated in Table 40. Fourteen persons, or about one fifth of the handicapped, about whom this information is available, never leave the house at all.

III. Housing Conditions and Transport Problems

Six and one-half percent of the sample, or 1,199 persons, were found to be physically handicapped. From this group 120 had to be excluded from the analysis because of lack of concise health information, and information about housing and transport conditions was not available for another 169 persons. This report thus includes information about housing and transport conditions for 910 physically handicapped persons 15 to 61 years old and living in private households.

The sample was taken in such a way that the numbers may be multiplied by 147 to show the numbers for the whole population in these age groups in private households. When evaluating the numbers given for the whole population, it should be remembered that they are minimum numbers. If information about housing and transport conditions had been available for the two groups of 120 and 169 physically handicapped persons, the numbers given below would no doubt have been significantly greater.

It is shown in Chapter 1 that the relative number of physically handicapped persons who have their own apartments is the same as for the rest of the Danish population. Seven persons in the sample, corresponding to about 1,000 physically handicapped in Denmark, live in one room and do not have access to a kitchen.

The distribution of the physically handicapped in villas or terrace houses, blocks, and country properties is about the same as for the whole population. The "typical flat" is, however, smaller for the physically handicapped than for the rest of the population (Table 1).

The average number of occupants per flat and per room is somewhat larger for the physically handicapped than for the rest of the population (Table 2). There are relatively more overcrowded flats among the handicapped than among the rest of the population. The problem of overcrowded dwellings is singled out for special consideration in Chapters 3 and 4.

Chapter 2 deals with heating and sanitary facilities. Eighty-one physically handicapped persons in the sample, corresponding to about 12,000 handicapped in the whole population, live in dwellings without running water. Baths, water closets, and central or district heating are installed in only 41, 79, and 43 percent, respectively, of the dwellings of the physically handicapped (Tables 3, 4, 5, and 6). The percentages are highest for dwellings in blocks, somewhat lower for villas and terrace houses, and lowest for country properties.

These numbers represent a standard significantly lower than for the rest of the population.

The possibility of improvements in housing conditions is not very optimistically considered by the physically handicapped themselves. For example, 53 percent of those in dwellings without running water and 51 percent of those in dwellings with the lavatory placed outside the house answer "no" to the question of whether their dwelling could be improved in such a way that the effects of their illness would be relieved.

There is a relative surplus of older people among the physically handicapped. This leads to a certain relative surplus of older dwellings, which are often of low quality. Closer examination shows, however, that this fact can explain only part of the difference in the average quality of dwellings among the physically handicapped and among the rest of the population (Tables 7 and 8). The lower average income of the physically handicapped compared with the rest of the population seems to be one of the main causes for the lower average quality of their dwellings.

In Chapter 3 a dwelling is defined as overcrowded when it has two or more persons per room. Sixty-five physically handicapped in the sample were found to be living in overcrowded dwellings. This means that about 10,000 physically handicapped in Denmark are living in dwellings that are too small (Table 9).

These overcrowded dwellings are also of a significantly lower quality compared with the rest of the dwellings of the physically handicapped, as far as running water, bath, water closet, and central or district heating are concerned (Table 10). The material falls into two groups—a large group of dwellings (845 out of the 910 dwellings in the sample), the quality of which is somewhat lower than the average for the Danish population, and a smaller group of 65 dwellings, the quality of which is significantly lower than the Danish average, both with regard to space and installations.

Chapter 4 tries to answer the question "What are the characteristics of the people who live under these especially unsatisfactory housing conditions?" The physically handicapped with the lowest quality of dwelling are, on average, younger than the rest of the physically handicapped, which partly explains the fact that they also usually have more children per family (Table 11). The average income of this group is significantly lower than for the other handicapped, and there are relatively more

recipients of pensions and more unskilled workers among them than in the rest of the sample. Those who are gainfully employed have, on average, had more trouble in their work because of their handicap than have the handicapped who live in somewhat better dwellings. The most frequent handicap is back insufficiency, which is often accompanied by psychological troubles. Further, the handicapped in the lowest quality dwellings live more isolated from other people than the rest of the handicapped.

Which of these factors could explain why just these 10,000 physically handicapped persons are found in the dwellings of the lowest quality? The answer is that there seems to have developed a "vicious circle" of unsatisfactory housing conditions and physical, psychological, and social handicaps.

The transport problems of the physically handicapped, which are discussed in Chapter 5, concern both outdoor transport and moving about indoors.

Analysis of indoor transport problems is limited to the physically handicapped who have serious difficulties in walking. Thirty-four persons in the sample have a wheelchair or say they need one; another 11 handicapped are able to move around in the flat only by help of crutches, splints, or sticks. This means that about 6,600 physically handicapped in Denmark aged 15 to 61 years have serious troubles with indoor transport.

About 28 percent of the physically handicapped live in flats that are not level with the main entrance of the house (in the cellar, on the first floor, second floor, and so forth). In the whole population about 4,000 physically handicapped with walking difficulties have to walk up steps to the third floor or higher in order to get to their flat (Table 12).

There are in Denmark about 2,000 physically handicapped people who never leave the home (Table 13). Furthermore, only just over one fifth of the physically handicapped who have a special need for a car possess one. The cars owned by physically handicapped people are very often too small and inadequate for their needs.

Public and private institutional possibilities, if they were used, would probably cover the transportation needs to a large extent. The need for larger and stronger cars for the handicapped seems, however, to lie beyond present institutional possibilities.

The possibilities of improving the housing of the physically handicapped are also rather extensive. The public can support the financing of building or rebuilding. Several private organizations are giving substantial financial and advisory help for these purposes.

On the other hand, the utilization of these possibilities requires that the municipalities, the building societies, and the physically handicapped have both initiative and an intimate knowledge of rather complicated rules and practices. This is not always the case.

Moreover, a large part of the institutional effort is characterized by a wish to make normal dwellings especially suitable for physically handicapped people. Certain existing laws explicitly state that help for improvement can only be given when the dwelling is already of a certain "modern" standard.

The wish to make normal dwellings especially suitable for physically handicapped people must, of course, influence the policy in the long run, if the housing problem is not to disturb the rehabilitation of physically handicapped.

But one of the main findings of this analysis is that the dwellings of the physically handicapped are, on average, inferior to normal dwellings, and that at least about 10,000 physically handicapped in Denmark live in dwellings that are significantly inferior to the average. Therefore, the problem in the short run seems to be primarily to help these 10,000 physically handicapped people get normal dwellings of a suitable standard. This problem can hardly be solved within the framework of existing institutional programs.

IV. Work and Employment

Chapter 1 of this volume explains in detail the collection of material and the random sampling. In addition, the chapter presents some main characteristics of the occupational conditions of the physically handicapped.

Eighty-one percent of the men and 37 percent of the women in the A group indicate that they are usually gainfully employed, either in "main occupation" (that is, twenty hours weekly as a minimum) or in a sideline (less than twenty hours weekly). This occupational frequency is lower than that of the normal group, where 93 percent of the men and 56 percent of the women are gainfully employed. Among the gainfully employed physically handicapped persons there is a relatively high number of self-employed persons, but this is explained by the large number of handicapped in the oldest age groups.

The gainfully employed handicapped, by and large, carry out the same occupational functions as the nonhandicapped. Furthermore, there are only small differences between the physically handicapped and the normal group with regard to industrial distribution.

In other words, the physically handicapped can be found fairly evenly dispersed in all professional categories, functions, and industries.

Working conditions of the physically handicapped are further outlined in Chapter 2.

As a rule, the gainfully employed physically handicapped work throughout the year. Unemployment among the physically handicapped was insignificant in 1961/62, as it was in the total population that year. Only 2 percent of gainfully employed physically handicapped indicated that they had less than forty working weeks during the year preceding the interview.

Part-time occupation, in this study defined as employment less than thirty hours a week, is relatively rare among physically handicapped men. Only 3 percent of all gainfully employed physically handicapped men have part-time employment. It is more frequent among the women, where 30 percent work part time.

The effects of physical handicap on employment are, among other things, illustrated through the changes in occupational functions and working time caused by the physical handicap. Fifty-five percent of the physically handicapped gainfully employed men and 74 percent of the women have had no changes in occupations, functions, or working time as a consequence of their physical handicaps. Only for 15 percent of the men and 10 percent of the women has occupation changed as a direct consequence of the handicap.

However, the consequences may also manifest themselves otherwise than through direct change of occupation or function. Thus 65 percent of the men and 57 percent of the women indicate that they are hampered in their work by their handicap. As far as the men are concerned, this applies particularly to unskilled workers and self-employed persons (80 percent of these groups indicate that they are hampered in their work). The effects are less perceptible for the salaried employees, of whom only 46 percent feel hampered in their work by the physical handicap.

One third of all the gainfully employed physically handicapped informed the interviewer that their employer or colleagues had shown a positive attitude toward them with regard to the organization of the work and the like, as a consequence of their handicap.

Most of the physically handicapped are satisfied with their work. About 60 percent indicate that they like their work. About one fourth of the men and one third of the women voiced somewhat greater reservation.

Evidently the more severely handicapped are more satisfied with their work. Thus, it is evident that among persons with a degree of disability ranging above 30 (cf., the discussion of degree of disability in Chapter 2), 83 percent indicate that they like their work, that they feel that they are the right persons in the right places, and that they do not feel that their work is an unpleasant burden. This phenomenon seems surprising, because the presumption might be that the most severely handicapped might have major troubles in performing their daily work and hence feel the inconvenience more acutely. It may be that the experience of being able to keep up a job and cope with it holds a strongly positive value for the severely handicapped person.

It is an important part of the study to relate the severity of physical handicap to employment and occupational adjustment. Therefore it is considered essential to base the study on an objective standard of the severity of the physical handicap. In this connection it has not been possible to use any standards constructed previously—for instance, the degree of invalidity used by the accident insurance companies or the concept of "occupational disablement" which is used as the basis for determining the amount of disablement pensions. Therefore, a new standard of "degree of disablement" was developed in this study. An analysis of the degree of disablement is presented in Chapter 3.

Persons with diseases of the lungs, the heart, and the circulation are generally among those having the severest physical handicaps—that is, high degrees of disablement. Persons with back insufficiencies are generally less physically handicapped than persons of the other groups.

An analysis of the connection between degree of disablement and occupational income has been made. It shows that the number of physically handicapped who are gainfully employed decreases with increasing degree of disablement. The incomes of the gainfully employed alone show no clear and systematic connection with degree of disablement. In other words, a severe physical handicap makes it difficult to keep employment, but if the physically handicapped person is able to keep his employment despite his handicap, he will usually earn a normal income. Adaptation in the form of reduced working time, irregular occupation, lower piece-work rates, and so forth occurs seldom among the physically handicapped.

These observations are in contrast to the concept of "occupational disablement" mentioned above. This concept assumes that occupational adaptation generally leads to reduced income—actually, this kind of adaptation is found only rarely.

In Chapter 4, the backbone of the report, a study is made of the factors that influence the possibilities of the physically handicapped in keeping gainful employment despite their handicap. The following factors play the biggest role: former working functions of the persons in question, degree of disability, school education, vocational training, and, finally, certain psychological characteristics, especially self-reliance and "self-expectation."

With increasing degree of disability, the occupational frequency decreases. This holds true for men and women.

There is a higher occupational frequency for persons with physically light work, for instance, in the form of superior functions, office work, and so forth, than for persons with heavy work, especially of persons with purely manual functions.

Education is an element of great importance. Practically all the physically handicapped men who have graduated from or gone beyond middle school were gainfully employed at the time of the study. Correspondingly, the women who have graduated from or gone beyond a "Realskole" have a very high occupational frequency.

Persons with a proper vocational training in the form of an academic education, other advanced training, or training as skilled workers are able to keep their trade employment to a great extent. This even holds true for persons with severe physical handicaps. Persons who have participated in professional courses and the like, but without proper vocational training, constitute a medium group. The occupational frequency is relatively low for persons without any systematic vocational training or special courses.

Among the psychological elements, self-reliance and positive self-expectation are of paramount importance—that is, a strong self-reliance and strongly positive self-expectation generally go hand in hand with a high degree of occupational frequency, while a strongly negative self-expectation generally indicates a low occupational frequency. The latter also applies to persons who are characterized by fear or self-distrust and those who are depressed by their physical handicap.

The interaction of the various elements influencing the trade employment of the physically handicapped has been dealt with in a special section. Thus the interaction of degree of disablement and the other elements has been studied. The major results are the following:

Men who have completed "Realskole" or higher education seem to be able to keep up their employment, regardless of the degree of disability. All other groups are relatively sensitive to the degree of occupational disability—that is, the occupational frequency strongly decreases when the degree of occupational disability increases.

Women who have graduated from a "Realskole" or have had advanced training have a relatively high occupational frequency. Their occupational frequency shows a slight tendency to decrease, however, with an increasing degree of disability. It is found that men with proper vocational training keep up a high occupational frequency regardless of degree of physical handicap. Men who have taken shorter courses to acquire skills have a high occupational frequency when the degree of occupational disablement is low. Occupational frequency strongly decreases as disablement increases, ending up on a low level. Finally, persons without any vocational training have a comparatively low occupational frequency for all degrees of disability.

Women with some training, regardless of its kind and length, turn out to have a relatively high occupational frequency even for groups with comparatively high degrees of disability. Women without any vocational training show a lower occupational frequency, and the occupational frequency proves to decrease somewhat with increasing degree of occupational disability.

Besides the educational elements, psychological conditions play a certain part—especially the handicapped person's conception of his abilities to cope with present and future difficulties. No matter whether this is expressed in an index of self-confidence or in an index of negative or positive self-expectation, it largely seems to be the same element—the person's conception of his own possibilities—that is the most significant

in determining how a physically handicapped person manages. The connection between the occupational conditions of the handicapped and this element may largely be summarized in the following way:

For persons with physical handicaps involving a degree of occupational disablement below 10 percent, the possibilities of obtaining gainful employment will generally be very good, unless the person in question has an extremely negative judgment of his future possibilities. For persons with somewhat more severe handicaps the possibilities of obtaining gainful employment or keeping employment will also be comparatively good, but the lack of self-confidence or a negative judgment of their own possibilities seem to have greater influence the more severe the handicap.

This is supposedly due to the fact that the coincidence between physical handicap and lack of self-confidence plays a significant part in determining whether the individual will lose gainful occupation. This indicates that persons with a comparatively slight physical handicap will only be without employment when their self-confidence is weakened. Thus it is assumed that lack of self-confidence or low judgment of self-ability should generally be regarded as a factor in the employment of the handicapped. In general, a physical handicap will not be occupationally disabling, unless the handicap involves a degree of occupational disablement of above 100 percent. Regarding the other physically handicapped, *the physical disability generally only involves occupational disability if it coincides with the lack of training or with the lack of positive judgment of self-possibilities.*

This means that rehabilitation authorities and institutions, backed up by handicapped persons' favorable judgment of their own abilities and strength, have a good chance to obtain satisfactory results.

The need for vocational rehabilitation for the physically handicapped is difficult to evaluate, partly because there is some uncertainty about criteria for determining the need for rehabilitation. Any figure for the need for rehabilitation based on the present study must be regarded a minimum figure.

We have attempted to determine the minimum need for rehabilitation. In this connection the following circumstances should be specially emphasized.

1. More than 70,000 physically handicapped in Denmark are unemployed.
2. At least 58,000 of these persons are not physically incapacitated for work.
3. At least 31,000 of these persons have a joint family income at or below disability pension level (5,000 to 10,000 D.kr.), and there are at least 4,000 persons with a total income below 5,000 D.kr.
4. At least 11,000 of the 31,000 are men who, as a general rule, do not perform any household functions.
5. At least 62,000 physically handicapped are gainfully employed.

6. About 70 percent of these persons, or at least 43,000, have work that does not agree with medical requirements.

7. Only a small minority of these persons have changed their occupations or undergone any profound vocational adaptation because of their physical deficiency.

8. At the time of the examination few had had contact with any rehabilitation agencies.

9. Seventy-five percent of the physically handicapped men and 63 percent of the women whose work is assumed to damage their health state that their working ability is reduced by their physical handicap.

On this foundation the total minimum number of persons in need or rehabilitation is calculated to be about 72,000 physically handicapped, of whom 31,000 are unemployed, and who need to obtain such employment. The 41,000 who are gainfully employed must be presumed to need change of occupation or better adaptation to the conditions of their jobs.

ILLUSTRATIONS AND TABLES

II. Some Major Results of the Study

Table 1
Persons Above 15 Years in the Enumerated Sample Distributed by Sex and Age, Compared with Corresponding Figures from the 1960 Census

	Males		Females	
Age	Enumerated Sample	1960 Census	Enumerated Sample	1960 Census
15–19	193,011	197,236	179,928	189,142
20–24	115,395	153,802	130,389	150,174
25–29	128,037	138,479	136,416	139,658
30–34	133,770	141,174	139,650	144,085
35–39	149,793	152,208	154,350	256,430
40–44	150,234	150,254	165,816	153,007
45–49	149,058	150,753	159,936	154,030
50–54	152,145	144,225	143,472	148,970
55–59	121,128	125,136	133,329	133,781
60–64	108,633	106,167	119,364	118,532
65	211,092	224,914	244,167	262,833
Total	1,612,296	1,684,248	1,706,817	1,750,642

Table 2
Distribution of Occupations in the Enumerated Sample, Compared with the Corresponding Figures from the 1960 Census

	Enumerated Sample	1960 Census
Agriculture, fishing, etc.	15.2	17.6
Manufacturing	29.8	30.2
Public utilities, etc.	0.9	0.7
Building and construction	15.1	15.4
Wholesale trade, etc.	3.6	3.8
Retail trade	9.5	8.1
Financial institutions, insurance, etc.	2.1	2.0
Administration, professions, etc.	13.5	13.5
Other service industries	8.5	6.7
No information	1.8	2.0

Table 3
All Persons above 15 Years in the Enumerated Sample Distributed by Group of Municipalities, Compared with the Corresponding Figures from the 1960 Census

	Males		Females	
	Enumerated Sample (pct.)	1960 Census (pct.)	Enumerated Sample (pct.)	1960 Census (pct.)
Capital	20.9	20.4	23.4	23.4
Capital's suburbs	8.9	8.8	9.1	8.8
Provincial towns with suburbs	29.8	29.2	31.2	31.5
Urban areas	2.9	3.1	3.3	3.2
Rural areas	37.5	38.5	33.0	33.1
Total	100.0	100.0	100.0	100.0

Table 4
All Persons Above 15 Years in the Enumerated Sample Distributed by Geographical Areas, Compared with the Corresponding Figures from the 1960 Census

	Enumerated Sample		1960 Census	
	Number of Persons	As a Percentage	Number of Persons	As a Percentage
Capital	735,588	22.2	752,467	21.9
Capital's suburbs	299,733	9.0	303,151	8.8
Sealand	426,300	12.9	463,386	13.5
Lolland-Falster and Bornholm	119,658	3.6	134,310	3.9
Funen with surrounding islands	306,495	9.2	310,484	9.1
Jutland	1,431,339	43.1	1,471,092	42.8
Total	3,319,113	100.0	3,434,890	100.0

Table 5
Distribution of the Collected Material by Groups According to the Result of the Medical Judgment

	Males		Females		Total	
	Number	As a Percentage	Number	As a Percentage	Number	As a Percentage
Not physically handicapped	8,458	92.8	8,813	92.9	17,271	92.9
Probably not physically handicapped, inadequate medical data	46	0.5	75	0.8	121	0.6
Probably physically handicapped, inadequate medical data	72	0.8	48	0.5	120	0.6
Unquestionably physically handicapped	525	5.8	554	5.9	1,079	5.9
Total	9,101	100.0	9,490	100.0	18,591	100.0

Table 7
The Physically Handicapped Distributed by A, B, and C Groups

	Males	Females
A group	597	602
Persons for whom adequate medical data are not available	72	48
B group	525	554
Persons for whom adequate social and psychological data are not available	88	81
C group	437	473

Table 8
The Physically Handicapped As a Percentage of All Examined Persons Between the Ages of 15 and 61, Distributed by Sex and Group of Municipalities

	Males			Females			Males and Females		
	Unquestionably Physically Handicapped	Probably Physically Handicapped	Total	Unquestionably Physically Handicapped	Probably Physically Handicapped	Total	Unquestionably Physically Handicapped	Probably Physically Handicapped	Total
Capital	7.1	1.1	8.2	7.3	0.8	8.1	7.2	0.9	8.1
Capital's suburbs	3.9	0.8	4.7	2.3	0.1	2.4	3.1	0.4	3.5
Provincial towns and their suburbs	5.1	0.6	5.7	5.7	0.5	6.2	5.4	0.6	6.0
Urban areas	6.0	0.8	6.8	4.4	0.3	4.7	5.2	0.5	5.7
Rural areas	5.8	0.7	6.9	6.2	0.6	6.8	6.2	0.6	6.8
Total	5.8	0.8	6.8	5.9	0.5	6.4	5.8	0.6	6.4

Table 9

The Physically Handicapped As a Percentage of All Examined Persons Between the Ages 15 and 61, Distributed by Sex and by Geographical Areas

	Males			Females			Males and Females		
	Unquestionably Physically Handicapped	Probably Physically Handicapped	Total	Unquestionably Physically Handicapped	Probably Physically Handicapped	Total	Unquestionably Physically Handicapped	Probably Physically Handicapped	Total
Capital	7.1	1.1	8.2	7.3	0.8	8.1	7.2	0.9	8.1
Capital's suburbs	3.9	0.8	4.7	2.3	0.1	2.4	3.1	0.4	3.5
The rest of Sealand	4.5	0.7	5.2	5.3	0.5	5.8	4.9	0.6	5.5
Lolland-Folster, Bornholm	3.5	0.3	3.8	7.4	9.9	8.3	5.5	0.5	6.0
Funen with surrounding islands	6.2	0.8	7.0	6.1	0.4	6.5	6.2	0.5	6.7
East Jutland	5.5	0.1	5.6	6.6	0.3	6.9	6.1	0.2	6.3
North Jutland	7.3	1.2	8.5	5.2	0.6	5.8	6.2	0.9	7.1
West Jutland	5.3	0.5	5.8	5.5	0.2	5.7	5.4	0.3	5.7
South Jutland	7.9	1.5	8.4	6.8	1.3	8.1	7.2	1.4	8.6
Total	5.8	0.8	6.6	5.9	0.5	6.4	5.8	0.6	6.4

Table 14

All Examined Persons Distributed As a Percentage by Sex and by Marital Status and the Physically Handicapped Persons in the A Group Distributed by the Same Criteria

	Males		Females	
	All Examined Persons	The Physically Handicapped	All Examined Persons	The Physically Handicapped
Not married	29	17	23	14
Married	68	78	69	68
Actual cohabitor	1	1	1	1
Deserted	0	0	0	0
Separated	0	0	1	1
Divorced	1	3	3	6
Widowed	1	1	3	10
No information	0	0	0	0
Total	100	100	100	100

Table 16
The Physically Handicapped in the B Group Distributed by Sex, Physical Disablement, and Income

Intervals of Income	Males			Females		
	Not Physically Disabled	Physically Disabled	Physically Incapable of Work	Not Physically Disabled	Physically Disabled	Physically Incapable of Work
0– 999	-	5	1	-	5	1
1,000– 1,999	-	-	-	-	2	-
2,000– 2,999	-	5	-	-	5	-
3,000– 3,999	-	5	1	-	10	-
4,000– 4,999	1	5	1	-	16	2
5,000– 6,999	-	39	9	-	70	19
7,000– 9,999	1	83	7	2	60	6
10,000–14,999	3	96	6	2	85	15
15,000–19,999	3	66	1	-	86	7
20,000–29,999	1	69	-	-	57	7
30,000–49,999	2	18	-	2	15	1
50,000 and over	1	8	-	-	9	-
No information	3	74	10	-	66	4
Total	15	473	27	6	486	62
Average total income	22,300	15,700	8,100	20,333	14,732	12,060
Total average income		15,400			14,500	

Table 17

All Examined Persons and the Physically Handicapped in the A Group Distributed As a Percentage, by Sex and by Whether They are Gainfully Employed

	All Examined Persons		The Physically Handicapped	
	Number of Persons	As a Percentage	Number of Persons	As a Percentage
MALES				
Gainfully employed occupation (above 20 hours weekly)	8,408	92	470	79
Wives assisting in husband's trade	-	-	-	-
Family assisting in the trade	116	1	-	-
Housewives, pensioners, etc., in sideline (less than 20 hours weekly)	41	0	14	2
Not gainfully employed	603	7	113	19
No information	49	1	-	-
Total	9,101	100	597	100
FEMALES				
Gainfully employed in main occupation (above 20 hours weekly)	4,846	51	200	33
Wives assisting in husband's trade	1,199	13	69	11
Family assisting in the trade	74	1	4	1
Housewives, pensioners, etc., in sideline (less than 20 hours weekly)	468	5	21	4
Not gainfully employed	4,097	43	379	63
No information	79	1	2	0
Total	9,490	100	602	100

Table 18
All Examined Persons and the Physically Handicapped in the A Group Distributed As a Percentage by Sex and by Industrial Status

	Males		Females	
	Total	Physically Handicapped	Total	Physically Handicapped
Employed away from home:				
Salaried employees	21	14	17	8
Skilled workers	19	13	2	0
Unskilled workers	28	24	16	10
Self-employed	23	26	2	2
Employed at home:				
Wives assisting husbands	-	-	13	12
Family assisting in trade	1	1	1	1
Housewives	-	-	90	
Pensioners, etc.	1	18	3	23
Students	5	3	5	1
Others	1	1	1	2
No information	1	-	1	0
Total	100	100	100	100
N	9,101	597	9,490	602

Table 25
The Gainfully Employed Physically Handicapped in the C Group Distributed by Sex and by Whether the Handicap Affects Their Working Capacity

Degree to Which Working Capacity Is Affected	Number of Persons		As a Percentage	
	Males	Females	Males	Females
Small effect	105	50	34	42
Some effect	115	43	37	37
Much effect	87	23	28	20
No information	2	1	1	1
Total	309	117	100	100

Table 26
The Gainfully Employed Females in C Group Distributed by Percentage by Age and by Whether the Handicap Affects the Working Capacity

Age Group	Small Effect	Some Effect	Much Effect	Total	N
15–39	60	20	20	100	29
40–49	54	32	14	100	37
50–54	35	42	17	100	23
55 or over	18	53	29	100	28
Total	42	37	21	100	308

Table 27
The Gainfully Employed Physically Handicapped in the C Group Distributed by Sex and by Whether the Handicap Has Affected Promotion, etc.

	Number of Persons		As a Percentage	
	Males	Females	Males	Females
Handicap has affected promotion	95	27	31	23
Handicap has not affected promotion	187	79	60	68
Doubtful cases	25	11	8	9
No information	2	-	1	-
Total	309	117	100	100

Table 34
The Physically Handicapped in the C Group Distributed by Whether They Are Gainfully Employed and by Whether They Receive Public Allowances

	Males			Females		
	Gainfully Employed	Not Gainfully Employed	Total	Gainfully Employed	Not Gainfully Employed	Total
Receive no public allowances	258	21	279	91	173	264
Receive unemployment benefits	-	2	2	-	-	-
Receive allowances from accident insurance	1	2	3	-	1	1
Receive pensions from accident insurance	1	-	1	-	-	-
Receive disablement pension	37	95	132	11	154	165
Receive special disablement benefits	1	-	1	-	-	-
Receive widow's pension	-	-	-	8	16	24
Receive superannuation pensions	1	3	4	-	2	2
Receive allowances for widows, etc.	-	-	-	2	-	2
Receive allowances in accordance with the act of rehabilitation	1	-	1	-	1	1
Receive public allowances	5	1	6	4	2	6
Receive public allowances after rehabilitation	1	1	2	-	2	2
Receive other public allowances	1	2	3	-	-	-
No information	2	1	3	1	5	6
Total	309	128	437	117	356	473

Table 39
The Physically Handicapped in C Group, Distributed by Floor Level and Main Diagnostic Groups

	Difficulties in Walking	Back Insufficiency	Other Motorial Disorders	Disorders of the Sensory Functions	Cerebral Attacks	Disorders of the Heart & Respiratory System	Gastro-intestinal Disorders	Diseases of the Urogenital System	Diabetes and Other Metabolic Disorders	Other Handicaps
Without lift										
Cellar	2	1	2	-	1	1	-	-	-	-
Ground floor	199	195	145	54	43	183	52	17	64	53
First floor	27	29	26	20	9	36	8	11	11	17
Second floor	20	19	11	11	4	24	5	5	3	11
Third floor	26	21	19	7	5	18	2	1	8	15
With lift										
All floors	3	1	-	-	1	2	-	2	-	-
Total	277	266	203	92	63	264	67	36	86	96

Table 40
The Physically Handicapped in the C Group Distributed by Outdoor Transport and by Groups of Municipalities

	Capital	Capital's Suburbs	Provincial Towns With Suburbs	Urban Areas	Rural Districts	Total
	6	1	3	-	342	14
	10	4	60	8	48	130
	-	-	2	-	3	5
	27	8	64	7	74	180
	-	-	1	-	6	7
	45	15	36	2	105	203
	85	7	42	-	5	139
	6	3	2	-	13	24
	65	5	48	6	84	208
Total	244	43	258	23	342	910

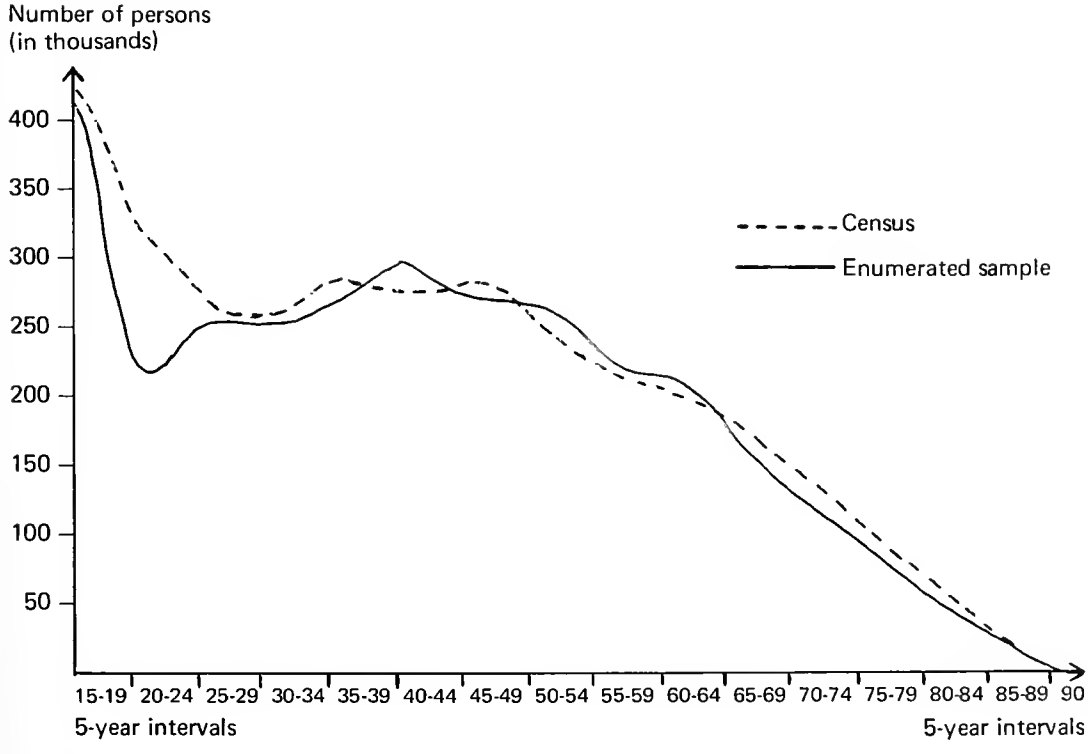

Figure 1. Comparison of Age Distribution of Enumerated Sample and 1960 Census

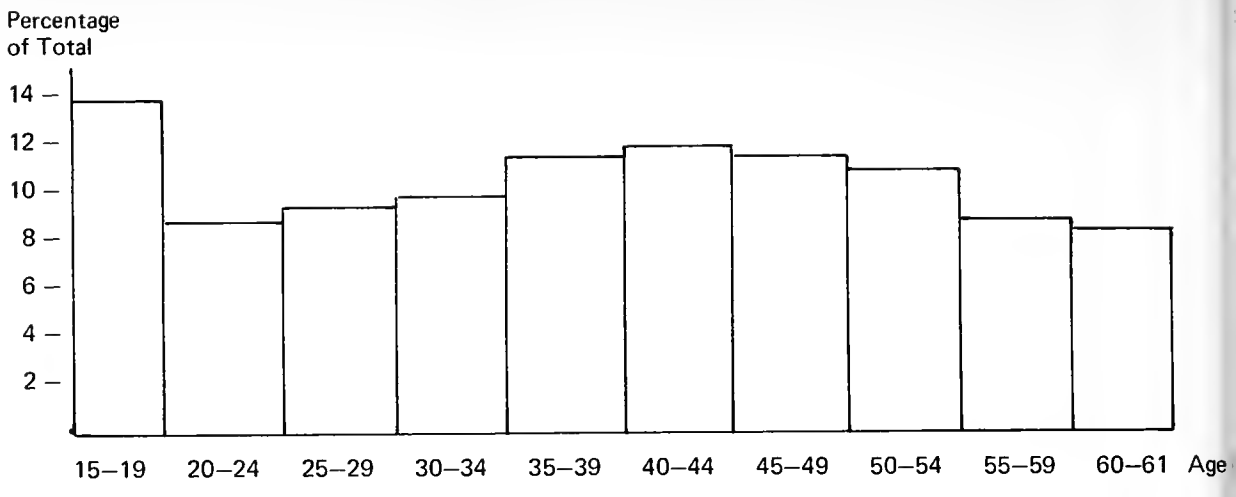

Figure 2. All Examined Persons, Handicapped and Not Handicapped, Distributed by Age Groups

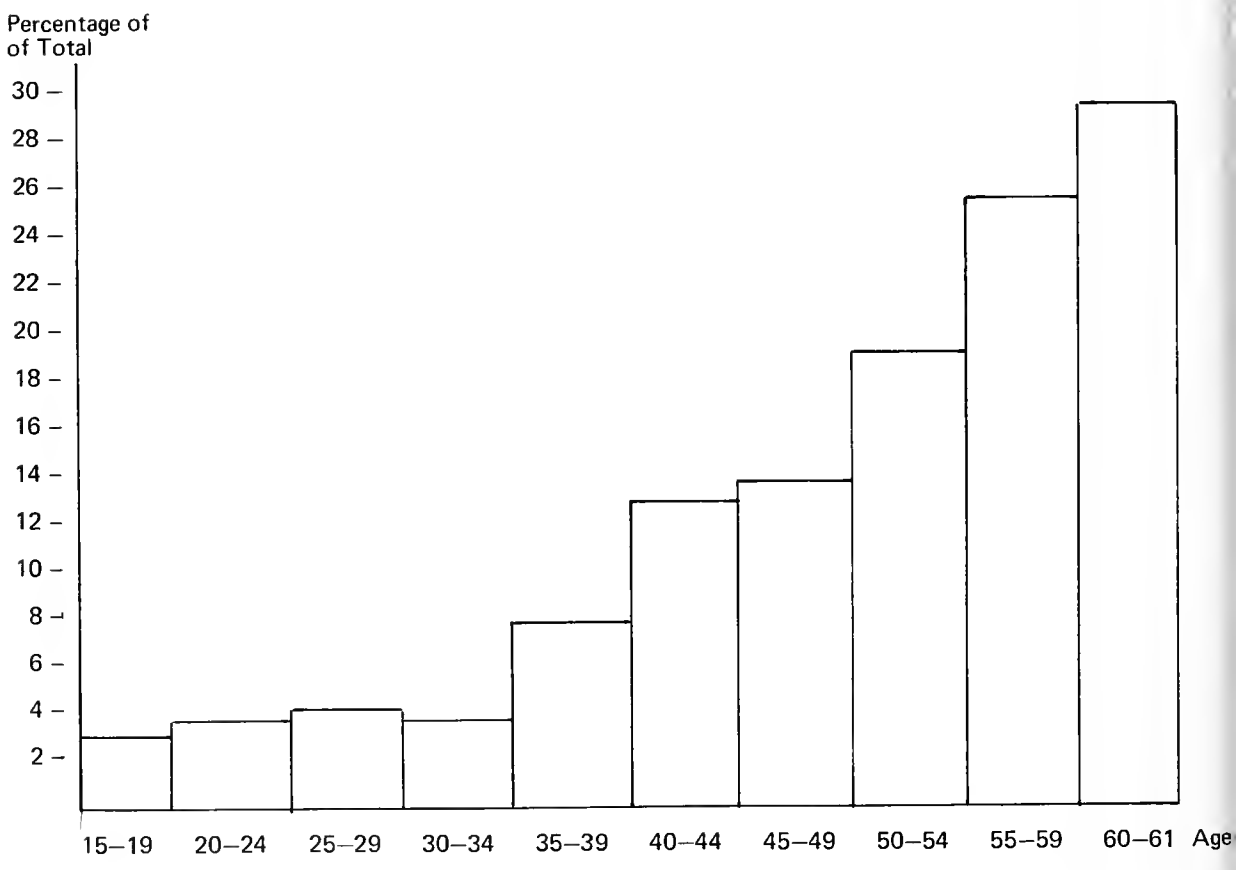

Figure 3. The Physically Handicapped Distributed by Age Groups

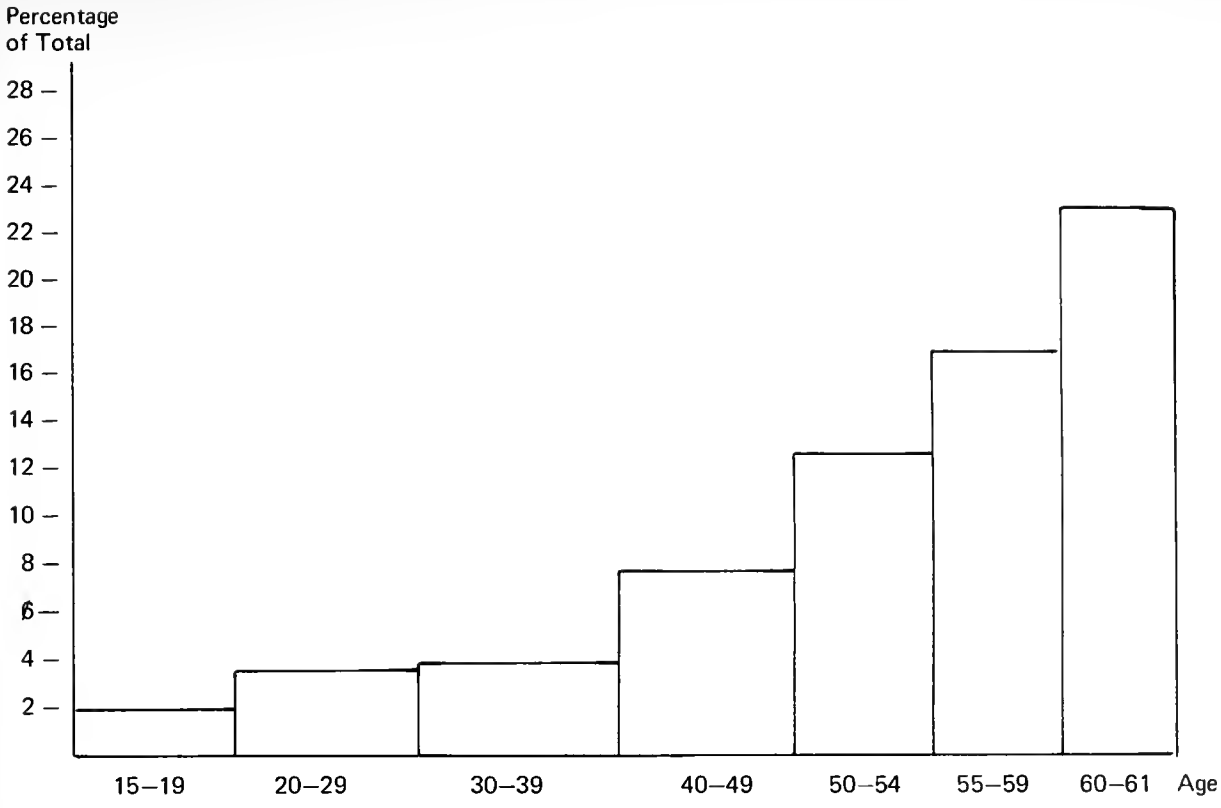

Figure 4. The Physically Handicapped Males As a Percentage of the Total. Distributed by Age Groups

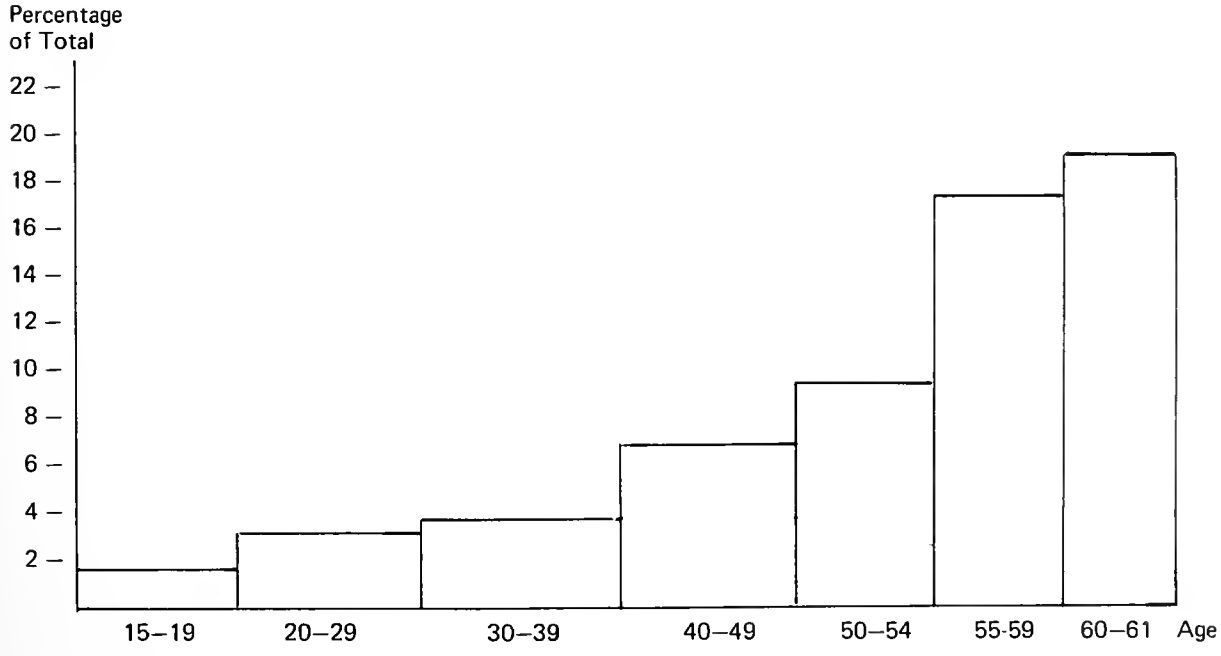

Figure 5. The Physically Handicapped Females As a Percentage of the Total. Distributed by Age Groups

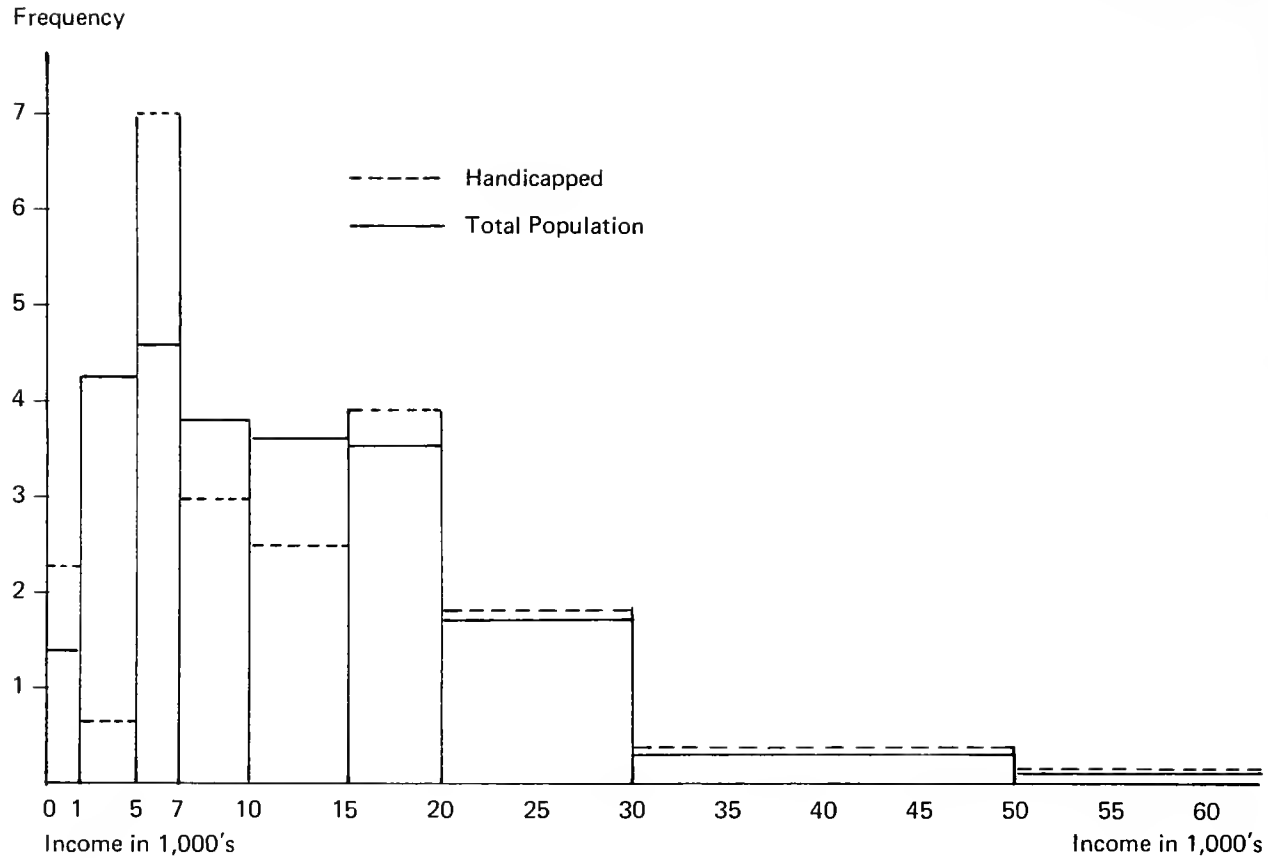

Figure 6. The Population in the Capital, Distributed by Income

Table 1

The Physically Handicapped Distributed by Number of Occupants and by Size of Flat

	Number of Flats with						
Number of Occupants	1 Room	2 Rooms	3 Rooms	4 Rooms	5 or more Rooms	Unknown Number of Rooms	Total Number of Flats
1	14	44	7	5	2	12	84
2	2	78	84	34	13	71	282
3	–	32	49	66	20	61	228
4	1	29	31	33	21	29	144
5	–	12	23	15	16	21	87
6	–	2	10	6	12	8	38
7 or more	–	1	5	3	5	6	20
Unknown	4	4	2	–	1	16	27
Total	21	202	211	162	90	224	910

Table 2

Density of Habitation, Distributed by Size of the Flats for the Physically Handicapped and for the Danish Population

	Average Number of Occupants per Flat		Average Number of Occupants per Room	
Size of Flat (number of rooms)	Physically Handicapped	Danish Population	Physically Handicapped	Danish Population
1	1.30	1.29	1.30	1.29
2	2.48	2.42	1.24	1.21
3	3.12	2.97	1.04	0.99
4	3.28	3.37	0.82	0.84
5 or more	4.15	3.97	0.83	0.79

Table 3

The Flats of the Physically Handicapped and of the Population Percentually Distributed by Sort of House and by Bathroom Conditions

	Flats of Physically Handicapped with Bath			Percentage of All Flats with Bath in September, 1960
	Bathtub	Shower Only	Total	
Villa or terrace house	21.7	18.9	40.6	50.4
Block	19.1	24.8	43.9	45.5
Country Property	19.8	11.1	30.9	32.2
Total	20.0	20.6	40.6	48.2

Table 4

The Flats of the Physically Handicapped and of the Population Percentually Distributed by Sort of House and Lavatory Conditions

	Flats of Physically Handicapped						Percentage of Flats of Physically Handicapped with Water Closet	Percentage of all Flats in Denmark with Water Closet in Sept., 1960
	Water Closet Situated in			Closet Without Water Situated in				
	Flat	House	Court	Flat	House	Court		
Villa or terrace house	43.1	35.4	1.4	1.4	3.0	15.7	79.9	78.8
Block	72.3	15.9	4.9	4.6	0.3	2.0	93.1	97.9
Country property	21.0	22.2	1.2	2.5	5.6	47.5	44.4	47.1
Total	51.2	25.2	3.0	2.6	2.3	15.7	79.4	83.0

Table 5

The Flats of the Physically Handicapped and of the Population Percentually Distributed by Sort of House and by Way of Heating

	Central Heating			Stove or Fireplace			Percentage of Flats of Physically Handicapped with Central or District Heating	Percentage of All Flats in Denmark with Central or District Heating
	District Heating	Solid Fuel	Oil	Solid Fuel	Oil	Other Usage		
Villa or terrace house	7.3	24.6	11.6	43.3	13.0	0.2	43.5	44.5
Block	11.3	20.6	15.9	30.2	20.3	1.7	47.8	56.2
Country property	–	20.4	4.9	61.7	12.4	0.6	25.3	25.5
Total	8.3	22.2	12.1	40.9	15.5	1.0	42.6	47.0

Table 6

Physically Handicapped in Homes with Physically Demanding Heating Requirements, Distributed by Type of Disability

	Central Heating	Stove or Fireplace	Total
Difficulties in Walking	19.8	46.2	66.0
Back insufficiency	22.9	43.6	66.5
Other motorial disorders	21.7	42.4	64.1
Disorders of heart and respiratory system	17.8	47.0	64.8
All physically handicapped	22.2	40.9	63.1

Table 7

Standard Calculation of the Influence of the Age Distribution on the Flats of the Physically Handicapped

	Age Distribution of the Physically Handicapped		Number of Flats Without Installation of:					
			Bath		Water Closet		Central or District Heating	
	Actual	Calculated	Actual	Calculated	Actual	Calculated	Actual	Calculated
15–19	18	125	6	42	1	7	8	55
20–24	31	82	17	45	4	10	18	48
25–29	32	88	21	58	6	17	20	55
30–34	32	92	14	40	5	14	14	40
35–39	57	102	32	57	10	18	36	64
40–44	104	107	53	54	22	22	54	56
45–49	124	106	66	56	16	14	71	61
50–54	178	93	110	57	41	21	103	54
55–59	228	87	147	56	54	21	137	52
60–61	106	28	72	19	27	7	63	17
Total	910	910	538	484	186	151	524	502
Actual part in percent	–	–	*59.4*	–	*20.6*	–	*57.4*	–
Calculated part in percent	–	–	–	*53.2*	–	*16.8*	–	*55.1*

Table 8

Percentage of Flats Without Bath, Water Closet, or Heating

	Without Bath (pct.)	Without Water Closet (pct.)	Without Central or District Heating (pct.)
Physically handicapped	59.4	20.6	57.4
Physically handicapped after correction of age distributions	53.2	16.8	55.1
The population (estimated numbers, as described above)	*ca.* 49.0	*ca.* 14.5	*ca.* 50.0

Table 9

Number of Overcrowded Flats for All Physically Handicapped in the Country, Living in Private Households (enumerated and rounded numbers)

Number of Rooms	
1	450
2	6,500
3	2,200
4 or more	450
Total	9,600

Table 10

Percentage of Flats with Installation of Running Water, Bath, Water Closet, Central or District Heating

	With Running Water	Bath	Water Closet	Central or District Heating
Overcrowded flats	87.7	36.9	73.8	36.9
Nonovercrowded flats	91.4	41.2	80.1	43.0
All flats of the physically handicapped	90.9	40.6	79.4	42.6

Table 11

All Physically Handicapped and the 65 Physically Handicapped with Especially Bad Housing, Distributed by Household Situation (Absolute Numbers)

	All Physically Handicapped	Physically Handicapped with Particularly Bad Housing Conditions
Living alone	84	–
Living with adults only	527	27
Living with children under 15	16	4
Living with adults and children under 15	257	34
No information	26	–
Total	910	65

Table 12

The Physically Handicapped Distributed by Type of Functional Limitation and the Situation of the Flat

Persons with:	Flats at Ground Floor or at Other Floors with Lift	Flats Out of Level with the Front Door Without Lift	Flats on Third Floor or over Without Lift	Total of First & Second Columns
Difficulties in walking	202	75	26	277
Back insufficiency	196	70	21	266
Other motorial disorders	145	58	19	203
Disorders in heart and respiratory system	185	79	18	264

Table 13

The Physically Handicapped Distributed by Outdoor Transport and by Industrial Status

Means of Transportation	Salaried Employees	Workers	Self-Employed	Housewives	Pensioners	Other & No Information	Total
Don't leave house	–	–	1	4	9	–	14
Wheelchair	–	–	–	–	4	1	5
Hand bicycle	–	1	1	–	5	–	7
Walking	11	16	7	38	45	13	130
Bicycle	21	64	21	23	29	22	180
Tram, bus, train	13	26	4	39	48	9	139
Motor vehicle	36	48	46	28	22	23	203
Other	1	3	2	9	8	1	24
No information	13	44	29	46	52	24	208
Total	95	202	111	187	222	93	910

SPATIAL LOCALIZATION BY THE BLIND *

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This research is concerned with the ability of blind people to orientate themselves within, and to localize aspects of, their spatial environment. Since vision, the most accurate kind of spatial information, is not available to the blind, they must base their localization-judgments upon information which is relatively less reliable. Nevertheless, the ability of blind people to perceive objects often appears quite uncanny to the sighted observer and it has variously been supposed that they have either developed their remaining senses to a higher degree of acuity than sighted people or have developed an extra sense of some kind with which they are able to localize stimuli in space (1). After vision, the most important of the spatial senses are tactile-kinesthesis (hereafter referred to as "tactile") and audition.

There is some uncertainty regarding the relative accuracies with which auditory and tactile stimuli can be localized since, to our knowledge, no directly comparable threshold estimates have been made. Stevens and Newman, however, estimated a value of approximately 12° of angle for the average error of localization of sound-sources in a situation in which the *S*s were required to make absolute judgments of the apparent positions of sounds presented in the horizontal plane (2). More recently, Mills has estimated a threshold-value of about 1° of angle for tones of 1,000 cps (3). Fitts estimated an average error of about 4° of angle in a situation in which the *S*s were required to reach out to touch targets with their index fingers (4). In both the Sevens and Newman and the Fitts studies, the *S*s made their judgments according to what might be called a "remembered visual context," and we suspect that a very wide range of threshold-values may be obtained when using such a method, depending upon how well the ordinates of the visual context have been learned or are recalled. In the Fitts experiment, moreover, strong visual anchoring stimuli in the form of two red lights placed in the frontal plane were present throughout. The presence of these stimuli insures that the judgment being made is not "intrasensory" but "intersensory," the tactile stimulus being localized with respect to the visual. Mills used what we shall call the "method of successive presentation," in which a tone is first presented in a standard position and then again after being displaced by a small distance to the left or right, *S*'s responses being made according to the apparent relative positions of the two stimuli. Such a method inevitably introduces a "time error," and as far as we know no research in audition has been conducted to estimate the extent of such errors for different time-intervals. intervening between presentation of standard and variable stimuli. The Mills estimate of the auditory threshold probably involves an "anchoring" effect also,

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since he used the method of constant stimuli, but this would not be a major objection if it is borne in mind when making comparisons between this and other methods of estimation. It is intended to consider these and other problems involved in estimating thresholds in a subsequent paper. Furthermore, in none of these studies was any attempt made to eliminate the proprioceptive context in which the *S*s were placed, and it therefore would appear that the judgments made in each case were not truly "intrasensory." Finally, each of the methods used in these studies is sensitive to the interval or step-size between stimuli and if this is badly chosen, it is possible to obtain almost any value for the threshold.

Specifically, the purpose of the present investigation is to measure the ability of blind *S*s to localize stimuli by sound and by touch, and to attempt to determine the nature of the information they utilize. The above considerations lead us to suggest that it is essential, in designing experiments for these purposes, *(1)* to use an appropriate stimulus-increment or step-size; *(2)* to control time-errors and "anchoring" effects by using appropriate psychophysical procedures; and *(3)* to exclude "spatial contexts" available in modalities other than the particular one under investigation.

METHOD AND PROCEDURE

Subjects. Five blind *S*s were used. Three of these had been blind from birth and were unable to distinguish between conditions of dark and bright sunlight. Two *S*s had had some pattern-vision until the age of about 6; one of these was probably able to distinguish between darkness and very brightly lighted conditions, the other was almost certainly unable to do so. Two *S*s were left-handed, the others right-handed; they had no obvious auditory defects. All of the blind *S*s were employed in the workshops of The Blind Institute, Kingston-upon-Hull, England. Five sighted *S*s were used as a comparison or control group; these were all university students who had no obvious visual or auditory defects.

Apparatus. The apparatus has been described fully elsewhere (5). Briefly, it consisted of a system of three bearings, each having the same center of rotation. Each of these bearings could be adjusted with an accuracy of ± 10° of angle in the horizontal plane. Mounted on arms attached to two of the bearings, for the present experiment, were a small hearing-aid earphone and a tactile-stimulus. The tactile-stimulus was effectively a soundless switch to which *S*'s index finger was guided by means of two brass rods fitted in the shape of a "V" on either side of it. This switch was so connected into an electronic circuit that either the auditory stimulus could be presented immediately it was touched or it could be presented independently. Control-rods attached to the bearings enable the arms on which the stimuli were mounted to be moved through an angular distance of 90°. Since a turntable upon which the *S*'s chair was mounted could be rotated through 90° also, the total range of the apparatus was about 180°. The apparatus was mounted in an anechoic and partially soundproofed room. Both blind and sighted *S*s wore dark goggles throughout the experiment. White noise was always used as the auditory stimulus.

Experiment 1

Our first task was to determine the relative ability of the blind *S*s to localize both tactile and auditory stimuli. To do this, the "method of successive presentation" was used in which a stimulus was presented first in a standard position and again after an interval of 2 sec during which time it had been moved into another position. The *S*s were required to judge the apparent relative positions of the two stimuli. In an independent series of experiments, in which the extent of time-errors was estimated for intervals between 1-30 sec, it was found that these errors were not appreciable until some 4 or 5 sec had elapsed between presentations.

Procedure. The *S*s were seated comfortably in the apparatus and instructed as follows:

Instructions. "I am interested to know how well you are able to localize the positions of auditory and tactile stimuli. This is the auditory stimulus [sound switched on]. If you will now reach out the index finger of your preferred hand and run it down between these guide wires you will feel the tactile stimulus. I shall let you hear or ask you to touch the first stimulus; after this either wait or drop your hand back into your lap. I will then change the position of the stimulus and allow you either to hear it or ask you to reach out to touch it again. All you have to do is tell me which of the stimuli, forst or second, appears to you to be farther to the left."

All the *S*s were given 20 trials in each condition before the experiment proper was started. During these practice trials, it was found that all the *S*s were able to reach out and to touch the tactile stimulus within a time-interval of 2 sec. The auditory stimuli were accordingly presented at 2-sec intervals also. To avoid building up "spatial-contexts" five positions of each *standard* stimulus were used; associated with each standard position were five positions of the *variable*. The data were collected in the form of frequency-distributions of responses over the five positions of each variable; they were analyzed by Spearman's distribution-method.

Results. The results of Experiment I are shown in Table I. In this table are entered the *variances* for both auditory and tactile localization judgments. Mean variances for blind

Table 1

Variable Errors (Variances) of a Group of Blind and Sighted S*s for Both Auditory and Tactile Localizations in Increments of 100 Minutes of Angle*

Auditory				Tactile			
Blind		Sighted		Blind		Sighted	
S	a^2	*S*	a^2	*S*	a^2	*S*	a^2
JC	3.76	*AC*	2.66	*JC*	1.41	*AC*	1.02
DF	2.87	*AL*	3.42	*DF*	0.52	*AL*	0.85
AS	2.59	*RW*	3.22	*AS*	0.96	*RW*	0.79
CP	3.26	*FG*	2.86	*CP*	0.83	*FG*	1.36
PS	3.49	*PC*	2.93	*PS*	1.11	*PC*	1.42
		$\overline{X}$	3.02	$\overline{X}$	0.97	$\overline{X}$	1.09
F	1.06				1.12		
P	>0.05				>0.05		

and sighted *S*s have been estimated and compared by calculating the *F*-ratio between groups. For neither auditory nor tactile localizations is this value significant, and, in fact, from a statistical point of view, these data could be pooled and considered as having been drawn from a single population of *S*s or responses.

Head-turning. The results of Experiment 1 suggest that there is no difference in the ability of blind and sighted *S*s to localize either auditory or tactile sources using these particular stimulus-conditions and this type of response. It should, however, be borne in mind that the response required was somewhat artificial. It is more usual, when making judgments of auditory localizations in particular, for people to turn their heads toward the apparent source of stimulation; this is also to some extent the case when making judgments of tactile localizations. It is, therefore, possible that if a more natural response could be used, such as allowing *S*s to turn their heads toward the source of stimulation, blind *S*s may prove to be more accurate than sighted *S*s.

Experiment 2

Built into the apparatus described above was a helmet mounted on a very freely running ball-race bearing. By fixing *S*'s head firmly into this helmet and by fitting a light aluminum pointer onto the back of the helmet, it was possible to observe the angular position of his head in the horizontal plane on an additional scale built into the apparatus.

Procedure. *S* was seated comfortably in the apparatus with his head fitted firmly in the helmet by means of screws which tightened a caliper mounted inside the padding. He was then instructed as follows:

Instructions. "I am interested to know how well you can localize both sound- and touch-stimuli, as before. This time all I wish you to do is either to listen to the sound or reach out to touch the tactile stimulus. As soon as you hear or touch the stimulus, simply turn your head directly toward it."

Twenty trials in each condition were given preceding the experiment proper. It was found convenient to present the auditory stimulus for 1 sec and this period appeared to be sufficiently long for *S* to turn his head toward the tactile stimulus. The increment between stimuli presented was 5°; thus there were 17 positions of presentation. Each stimulus-position was presented 6 times in randomized order, with 102 localizations in all. In an attempt to break down any proprioceptive context, *S* was rotated very slowly on the turntable over the whole range of random positions before every stimulus was presented. The data were collected in the form of error-scores in degrees; errors for localizing to the right of the actual stimulus-position were scored as positive, errors to the left were scored as negative.

Results and Discussion. The results of Experiment 2 are shown in Tables 2 and 3. In Table 2 the variances of error scores are entered for both auditory and tactile localizations. The mean variances for both blind and sighted groups have been estimated. Again the *F*-ratio indicates that there are no significant differences between the blind and sighted *S*s in their ability to localize auditory and tactile stimuli. In each modality, however, the blind group is very slightly superior, but whether this difference is real could only be considered by repeating the experiment with a much larger group of *S*s.

In Table 3 *constant errors* of the localizations are entered, the mean values having been calculated irrespective of sign. Here interesting differences between the two groups of *S*s are revealed that are very striking. After the *S*s are fitted into the apparatus, the sighted

Table 2

Variable Errors (Variances) of a Group of Blind and Sighted Ss for Both Auditory and Tactile Localizations in Increments of Degrees of Angle Using a "Head-turning" Response

Auditory				Tactile			
Blind		Sighted		Blind		Sighted	
S	a^2	*S*	a^2	*S*	a^2	*S*	a^2
JC	6.41	*AC*	8.21	*JC*	6.42	*AC*	7.11
DF	9.36	*AL*	6.79	*DF*	5.17	*AL*	8.93
AS	8.11	*RW*	9.84	*AS*	6.97	*RW*	4.62
CP	10.02	*FG*	11.76	*CP*	9.93	*FG*	6.17
PS	8.75	*PC*	7.44	*PS*	3.85	*PC*	6.29
$\overline{X}$	8.53	$\overline{X}$	8.81	$\overline{X}$	6.47	$\overline{X}$	6.62
F	1.04				1.02		
P	$\rangle 0.05$				$\langle 0.05$		

Ss tend to keep their heads straightforward; the blind *Ss* to turn their heads through a large angle and to keep them displaced throughout the experiment. The over-all effect of this is that constant errors for both auditory and tactile localizations are relatively larger for the blind *Ss*.

Intersensory Localizations. Blind people appear to be able to orientate themselves in space using a combination of auditory and tactile cues; for them, audition seems to be something more than an "attention" mechanism, which it is very largely with sighted people. Hunter has suggested that the spatial senses remaining to the blind are more "tightly organized" than the same senses of the sighted (7). One way of considering the hypothesis relevant to such organization would be to consider the "intersensory" localization ability of blind *Ss* in a situation in which stimuli in *different* spatial senses are localized mutually.

Table 3

Constant Errors of a Group of Blind and Sighted Ss for both Auditory and Tactile Localizations in Increments of Degrees of Angle Using a "Head-turning" Response

Auditory				Tactile			
Blind		Sighted		Blind		Sighted	
S	*CE*	*S*	*CE*	*S*	*CE*	*S*	*CE*
JC	−13.85 (0.25)	*AC*	+5.07 (0.29)	*JC*	− 9.58 (0.25)	*AC*	−3.62 (0.27)
DF	−18.72 (0.30)	*AL*	−1.26 (0.26)	*DF*	−12.47 (0.23)	*AL*	+2.42 (0.30)
AS	+20.33 (0.29)	*RW*	−3.58 (0.31)	*AS*	+10.08 (0.26)	*RW*	−0.23 (0.22)
CP	−10.06 (0.32)	*FG*	+1.93 (0.34)	*CP*	− 8.41 (0.32)	*FG*	−1.62 (0.25)
PS	+12.08 (0.30)	*PC*	+7.29 (0.27)	*PS*	+ 6.00 (0.20)	*PC*	+4.67 (0.25)
X	15.19 (0.29)	X	3.83 (0.30)	X	99.31 (0.25)	X	2.51 (0.26)

Experiment 3

In Experiment 3 the *S*s were placed in the apparatus and instructed as follows:

Instructions. "I am interested to know how well you can localize stimulus-cues of different kinds presented at the same time. If you reach out the index finger of your preferred hand you will feel the tactile stimulus, immediately you touch it you will also hear a noise. All you have to do is tell me which of the two stimuli is farther to the left. All you need to say is 'touch' or 'sound.' You will hear the sound for 1 sec; when it stops, drop your hand back into your lap.

Twenty trials were given to insure that the *S*s understood the instructions before the experiment proper was started. The method used for presenting the stimuli was especially developed for investigating intersensory localizations. First, the technique used for breaking down spatial context-effects which has been described above was used. In addition to this, it was necessary to measure and offset intersensory constant errors, since distributions of intersensory localizations are not normal for *S*s with appreciable constant errors. This was done by the "staircase" method of limits that the extent of the constant error would be known (8). The procedure was then continued by the method of constant stimuli, using tactile and auditory stimuli, in turn, as standard and variable to observe the effects of any residual spatial contexts. Since intersensory constant-errors fluctuate in time (that is, are *not* constant), it is necessary to repeat this procedure at least every 50 trials. As far as we know, this is the only acceptable procedure that can be used for investigating intersensory localizations, since it insures that distributions of response judgments are essentially normal and remain so in spite of fluctuating constant-errors (9). This method also allows consideration of sources of nonrandomness in sequences of response-judgments, a problem which will be the subject of a subsequent paper.

Results and Discussion. The results of Experiment 3 are shown in Tables 4 and 5. They appear to indicate an extrachance difference between the abilities of blind and sighted *S*s in their ability to make intersensory locations. If this difference, however, is real, it is in a direction *opposite* to that which would be predicted on any hypothesis which implied that

Table 4

Variable Errors (Variances) of a Group of Blind and Sighted Ss for Tactile Auditory Intersensory Localizations in Increments of 100 Minutes of Angle

Blind			Sighted		
S	a^2		*S*	a^2	
JC	2.44		*PW*	11.60	
DF	1.17		*CW*	0.30	
AS	0.62		*JF*	3.31	
CP	240.00		*AR*	38.50	
PS	510.00		*DH*	0.85	
$\bar{X}$	150.85		$\bar{X}$	10.91	
F		13.8			
P		> 0.025			< 0.010

Table 5

Constant Errors (Means) of a Group of Blind and Sighted Ss for Tactile-Auditory Intersensory Localizations in Increments of 100 Minutes of Angle

Means represent mean *CE* irrespective of sign. Figures in brackets are the *SE* of estimate of the individual *CE*.

Blind		Sighted	
S	$\bar{X}_{Tk-A}$	*S*	$\bar{X}_{Tk-A}$
JC	−2.46 (0.15)	*PW*	+1.46 (0.34)
DF	+0.13 (0.11)	*CW*	+1.85 (0.05)
AS	−1.87 (0.08)	*JF*	+0.52 (0.18)
CP	−5.66 (1.55)	*AR*	−3.23 (0.62)
PS	−1.23 (2.26)	*DH*	−2.69 (0.09)

blind people are more able to localize spatial stimuli than sighted people. The results could probably be explained on the basis of the effects of the conditions of reduced sensory input in which these experiments were conducted, but in the absence of any detailed evidence relating to the effects of reduced ambient stimulation upon blind people, this does not appear to be very convincing. We reaffirm, however, that there is a lack of congruence between these two spatial senses, since there are statistically significant differences between the apparent positions of stimuli in the auditory and tactile senses which are physically in the same place, in the case of four blind and four sighted *S*s. For one blind *S* (*CP*), the difference is greater than 9° of angle. This implies that auditory and tactile stimuli which are actually presented in the same position appear to be displaced, sometimes by extremely large angular distances.

These findings raise two questions. First, it seems unlikely that we are mistaken in assuming that blind people are able to utilize spatial information in some way superior to sighted people. We have, however, in the present experiments obtained no evidence in support of the view that auditory or tactile acuity is better than—or is in any way organized differently from—that of sighted people. Secondly, since there are constant-errors for localization of stimuli in different modalities, it must necessarily follow that there is conflict underlying the spatial information available to blind *S*s and this conflict may be resolved in some way.

Spatial Contexts. In previous research into problems of perception in conditions of intersensory stimulation, it was observed that the *S*s were able to localize stimulus-cues with respect to "spatial contexts" rather than with respect to comparison-stimuli. To eliminate the effects of these spatial contexts a special laboratory and apparatus were built and new psychophysical procedures were devised. The over-all result of these precautions was that the localizing situation was very different from the conditions in which blind people usually perceive spatial stimuli. It has been found possible in experiments with sighted *S*s to reintroduce an auditory context into the laboratory. This is achieved by placing a second hearing-aid earphone directly in front of the *S*s, slightly above and behind a position central with the arcs described by the arms bearing the stimuli. The earphone is energized with a 1,000 cps tone. A proprioceptive context may be reintroduced also by using one set of scales only for presentation of standard and variable stimuli.

Experiment 4

The previous experiments were conducted in conditions in which spatial contexts were not available. It is possible that blind people are able to utilize the information provided by such contexts more efficiently than sighted people and that it is because of this that they appear to be able to localize both auditory and tactile stimuli more accurately. The present experiment was designed to observe the effects of reintroducing spatial contexts into intersensory localization.

Procedure. The *S*s were fitted into the apparatus and instructed, as for Experiment 3, with the following additions.

Instructions. "In one part of this experiment you will hear a sound like a whistle; this will be straight ahead of you and it will remain always in the same position. Again, all you have to tell me is whether the noise, not whistle, or the touch stimulus is further to the left."

One hundred trials in each of the stimulus-conditions were given in blocks of 20, according to the procedure described for Experiment 3. The magnitudes of intersensory constant-errors were checked between blocks. The spatial context-conditions were randomized between blocks.

Results and Discussion. The results of Experiment 4 are entered in Table 6. To consider the influence of spatial contexts, the variances due to the three contextual conditions have

Table 6

Variances of Tactile-Auditory Intersensory Localizations of a Group of Blind and Sighted Ss in Different Spatial Context Conditions in Increments of 100 Minutes of Angle

Stimulus-Condition		Spatial Context-Condition									
		None	Aud.			T-kin.			Aud.-T-kin.		
Blind *Ss*	*S*	a^2	a^2	*F*	*p*	a^2	*F*	*p*	a^2	*F*	*p*
Aud. + T-kin.	*JC*	2.96	1.82	1.62	⟩0.05	1.21	2.43	0.05*	1.37	2.01	0.05*
	DF	0.92	0.86	1.07	⟩0.05	0.67	1.37	⟩0.05	0.83	1.11	⟩0.05
	AS	0.69	0.50	1.38	⟩0.05	0.42	1.64	⟩0.05	0.59	1.17	⟩0.05
	CP	275.00	174.20	1.58	⟩0.05	88.92	3.09	⟨0.05*	74.30	3.62	⟨0.01*
	PS	453.76	408.12	1.12	⟩0.05	121.60	3.45	⟨0.05*	110.10	4.12	⟨0.01*
T-kin. + Aud.	*JC*	2.79	0.66	4.23	⟨0.01*	1.74	1.00	⟩0.05	0.92	3.02	⟨0.05*
	DF	1.06	0.52	2.04	0.05*	0.86	1.23	⟩0.05	0.59	1.80	⟩0.05
	AS	0.85	0.42	2.02	0.05*	0.76	1.12	⟩0.05	0.38	2.24	0.05*
	CP	292.40	132.32	2.21	0.05*	229.64	1.27	⟩0.05	151.86	1.93	⟩0.05
	PS	458.13	131.80	3.48	⟨0.01*	293.16	1.56	⟩0.05	161.63	2.83	⟨0.05*
Sighted *Ss*	*S*	a^2	a^2	*F*	*p*	a^2	*F*	*p*	a^2	*F*	*p*
Aud. + T-kin.	*PW*	10.67	8.29	1.29	⟩0.05	2.12	5.03	⟩0.001*	3.37	3.16	⟨0.01*
	CW	0.41	0.72	1.76	⟩0.05	0.16	2.56	⟨0.025*	0.12	3.42	⟨0.01*
	JF	3.61	3.32	1.09	⟩0.05	1.37	2.64	⟨0.025*	1.62	2.23	⟨0.05*
	AR	36.29	30.91	1.18	⟩0.05	10.76	3.38	⟨0.01*	26.47	1.37	⟩0.05
	DH	0.91	1.23	1.35	⟩0.05	0.82	1.11	⟩0.05*	0.96	1.06	⟩0.05
T-kin. + Aud.	*PW*	10.93	11.62	1.06	⟩0.05	9.63	1.14	⟩0.05	8.76	1.25	⟩0.05
	CW	0.47	0.69	1.47	⟩0.05	0.59	1.25	⟩0.05	0.60	1.28	⟩0.05
	JF	2.93	3.21	1.10	⟩0.05	3.22	1.10	⟩0.05	3.02	1.03	⟩0.05
	AR	40.12	15.29	2.63	⟨0.025*	27.47	1.50	⟩0.05	18.29	2.20	⟨0.05*
	DH	1.11	1.17	1.06	⟩0.05	1.06	1.05	⟩0.05	0.71	1.57	⟩0.05

been divided into those for the condition in which no context is introduced in order to estimate the relevant *F*-ratio. These results suggest that no spatial context remains available for localizing since none of the within-*S* variances in the "no context" condition differ significantly. Introduction of an auditory context, however, in the condition in which the auditory stimulus is presented as the variable appears to improve accuracy in the case of all blind *S*s. Introduction of a proprioceptive context in the condition in which the tactile stimulus is presented as the variable, while being in each case in the right direction, is only significantly effective in the case of three blind *S*s. The results are similar for sighted *S*s in the tactile context-condition, the relevant variances being different in the case of three *S*s . Only one sighted *S*, however, appears to be able to utilize the auditory context although this appears to be used as a spatial context by two sighted *S*s when the tactile stimulus is presented as a variable.

Introduction of both contexts at the same time to blind *S*s improves accuracy in only 6 of the 10 conditions and appears to be less effective than would be expected from the results of the two individual context conditions. This outcome seems somewhat surprising until we recall that there were significant constant-errors for the intersensory localizations. What is probably happening in this condition is that there is conflict between the information providing the two contexts. This problem again raises the question of the nature of the mechanism by which conflict of this kind may be resolved.

Sensory Dominance. Evidence for constant-errors between the spatial senses observed both in intersensory localization and in spatial context experiments implies that there is conflict in localizing situations in which information of different kinds is available. We have suggested previously that this conflict is resolved by the operation of sensory dominant mechanisms. (10). To our knowledge perceptual mechanisms of this kind have not been studied previously with blind *S*s, but in view of their greater reliance upon auditory information it may be that the usual order of dominance is reversed and that this is the means by which apparent closer cooperation between the auditory and tactile senses is achieved.

Experiment 5

The method used previously in experiments on sensory dominance was to tell *S*s that two stimuli, say in vision and audition, were placed together when they were actually displaced by a small angular distance. The *S*s were then required to localize the "paired" stimulus with respect to a tactile stimulus. Since this method could not be used with blind *S*s, it was decided to employ again the head-turning response.

Procedure. The *S*s were fitted into the apparatus with their heads clamped firmly into the helmet. They were instructed, as in Experiment 2, with the following additional instructions: "This time I will allow you to touch and to hear a stimulus in the *same* position, just turn your head towards it as before."

Auditory, tactile and "paired" conditions were presented in randomized blocks. In the paired condition the tactile and auditory stimuli were displaced by 400 minutes of angle.

Results and Discussion. The results of Experiment 5 are shown in Table 7. The *constant* errors for four blind and five sighted *S*s suggest that the tactile sense is dominant, since the tendency is to localize more toward the apparent position of the tactile stimulus. In no case, however, is dominance *complete* and for one *S* (*AS*) the apparent position of the "paired" stimulus almost exactly bisects that of the individual stimuli. In the case of another

S (*JC*) the position of the paired stimulus appears to be beyond the position of the auditory stimulus. This may be taken as an indication of auditory dominance, but it should be noted that the constant-error of this *S* also fluctuates very widely. All sighted *S*s show complete tactile dominance. Hence, it seems that in general the usual dominance order is *not* reversed for blind *S*s, the implication being that in conditions of the kind used in this experiment the perceptual mechanisms brought into operation are the same in each group.

Table 7

Constant Errors (Means) for Localizations Using the Head-turning Response (in Degrees of Angle)

	S	T-kin.	Aud.	T-kin + Aud.	Dominant Stimulus
Blind	*JC*	− 7.72 (0.25)	−11.95 (0.25)	−13.02 (0.24)	Aud.
	DF	−11.32 (0.20)	−16.76 (0.28)	−12.37 (0.23)	T-kin.
	AS	+ 9.13 (0.29)	+22.26 (0.28)	+15.11 (0.30)	T-kin.
	CP	− 8.20 (0.29)	−10.29 (0.30)	− 8.74 (0.30)	T-kin.
	PS	+ 8.42 (0.22)	+14.49 (0.30)	+ 9.96 (0.26)	T-kin.
Sighted	*AC*	− 5.01 (0.25)	+ 6.04 (0.30)	− 5.37 (0.27)	T-kin.
	AL	+ 1.67 (0.25)	− 0.92 (0.31)	+ 1.47 (0.25)	T-kin.
	RW	+ 0.22 (0.30)	− 3.17 (0.27)	− 0.13 (0.25)	T-kin.
	FG	− 1.84 (0.34)	+ 2.04 (0.28)	− 1.72 (0.26)	T-kin.
	PC	+ 5.16 (0.27)	+ 6.73 (0.28)	+ 5.21 (0.30)	T-kin.

SUMMARY

To blind people, vision, the most accurate source of spatial information is not available; nevertheless, their ability to localize and to orientate themselves in relation to objects is often remarkably accurate. Two hypotheses have been advanced. The first is that the acuity of hearing is markedly improved; and the second that an extra sense of some kind is developed. The present investigation was designed to compare the auditory and tactile-kinesthetic localizing abilities of groups of blind and sighted *S*s. That the results gave no support for either of the hypotheses mentioned may be due to the fact that "spatial contexts" were not available to the *S*s. In experiments in which these contexts were reintroduced, it was observed that blind *S*s appear to be able to utilize the additional information provided—particularly in audition and rather less so in tactile-kinesthesis. This is, to some extent, the reverse of the tendency of sighted *S*s under similar conditions.

In a series of "intersensory" localizations, it was observed that both blind and sighted *S*s make significant constant-errors in localizing auditory and tactile stimuli when presented in the same place. This suggests that for blind *S*s, also, there must be conflict underlying these two spatial senses. Experiments on "sensory dominance" were conducted to establish which of these two modalities was dominant. Tactile-kinesthesis was generally found to be dominant for both blind and sighted, but for one *S*, who had been blind from birth, audition appeared to be the dominant modality.

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RETROLENTAL FIBROPLASIA *

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In the early 1950s, epidemiologic, clinical, and laboratory investigations led to the conclusion that the use of supplementary oxygen for small premature infants was associated with the development of retrolental fibroplasia. On the basis of this observation, recommendations concerning restriction in the use of oxygen for premature infants were formulated. There followed so sharp and prompt a drop in the incidence of RLF that the problem was generally considered to be solved.

New cases of RLF are, however, beginning to appear. Ten patients with severe RLF which developed since 1958 have been referred to the RLF research group at the Massachusetts Eye and Ear Infirmary. Oxygen therapy for premature infants has proved to be more complicated than had been anticipated. The problem is not merely one of limiting the administration of oxygen, but of making available to the infant sufficient oxygen for survival without increasing the risk of RLF.

The belief that oxygen in concentrations of less than 40 per cent is harmless needs reexamination. The early clinical trials involved "high" oxygen (greater than 40 percent) therapy of long duration and "low" oxygen (less than 40 percent) therapy of short duration, but did not include experiments with concentration and duration independent of each other (1-3). Some instances of moderate and even severe RLF have occurred in some of the "low" oxygen experiments (1, 2, 4).

On the other hand, in Kinsey's large cooperative study (which involved 786 infants in 18 cooperating hospitals) it was possible to investigate the effects of different concentrations of oxygen by separating the infants into groups for whom the average concentrations of supplementary oxygen differed by increments of 10 percent, but for whom the duration of treatment was essentially the same. Although the incidence of RLF was related to the *duration* of oxygen therapy, it was relatively unaffected by differences in average concentrations of oxygen in the range of 30 to 50 percent.

It is reasonable to assume that the danger of damage to the eyes is lessened in infants whose pulmonary exchange of gas is reduced. However, Cook (5) points out: "In room air, the oxygen tension in the alveoli of a hyperventilating infant with respiratory distress may be as high as 110-120 mm Hg at the same time that the arterial oxygen tension is low enough to result in cyanosis (that is, less than 55-60 mm Hg). When 40 percent or even 30 percent oxygen is

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administered, alveolar oxygen tensions may reach approximately 240 and 185 mm Hg, respectively. In a mildly cyanotic infant given such concentrations of oxygen, depending on the type of pathophysiologic change in the lungs, the possibility of raising the arterial oxygen tension above the safe (for RLF) level is very real. In this regard, it is worth remembering that full-term infants without respiratory difficulty have arterial oxygen tensions averaging 84 mm Hg, and that the arterial blood of premature infants may normally have even lower values. Infants with respiratory distress may have right-to-left shunts at the ductal level, in which case the blood going to the head (and eyes) would have a higher oxygen tension than that going to the periphery" (6).

Smith (7) advises that oxygen by given at the concentration which *just* suffices to relieve a newborn infant's cyanosis and that it be reduced or discontinued as soon as the cyanosis clears. Such a procedure, carried out literally, would require the constant attention of trained personnel (a service which would be difficult, but surely not impossible, to supply) or the use of an apparatus (not yet devised) which would automatically control oxygen flow in response to fluctuations in blood-oxygen tension.

It is sometimes necessary to give oxygen to premature infants who have episodes of apnea. In these cases, often, the lungs are normal; if so, the arterial oxygen tension will approach the alveolar oxygen tension as soon as regular respiration is reinstituted.

Last, it is possible, if unlikely, that the oxygen tension of the blood is not the only criterion to be considered, and that there is some other pathway through which excess oxygen damages developing retinal blood vessels. In any case, a few infants in our study group developed RLF in spite of what was regarded as a rigorous effort to use oxygen only during periods of cyanosis.

One can be certain that oxygen therapy has not caused eye damage only when the fundi are examined during and *after* completion of such therapy. Of the ten recent cases mentioned, although all the infants had low birth weights and had long hospital stays (2 to 3½ months), only two were diagnosed while the infants were still in the nursery. By contrast, virtually every case in our series (since 1949, when regular ophthalmoscopic examinations were instituted) was diagnosed while the infant was still in the Boston Lying-In-Hospital nursery. To be sure, ophthalmoscopic examination of small premature infants requires unusual skill and patience; nevertheless, it is desirable that the fundi of infants who have received supplementary oxygen be examined by competent observers.

The belief that RLF is no longer a problem (and certainly for several years it *was* almost nonexistent), combined with possible misunderstandings concerning oxygen therapy, seems to have generated an overrelaxed attitude toward the use of oxygen. For example, in the nursery records of the eight cases of RLF, only two indicate that an effort was made to use oxygen specifically for the treatment of respiratory distress. Furthermore, keeping of records is often inadequate.

In summary, the use of supplementary oxygen is accompanied by the risk of severe ocular damage. It is possible that no amount of caution will remove all risk; some infants

require oxygen therapy for survival, and some, perhaps, will develop RLF in spite of every practical effort to give oxygen only in the presence of cyanosis. It is clear, however, that if excess oxygen is used without awareness of its possible danger and without caution and constant vigilance, there will be RLF and blindness which could have been avoided.

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FAMILY FACTORS RELATED TO PLACEMENT OF MONGOLOID CHILDREN *

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THE PROBLEM

The birth of a mongoloid retarded child represents a crisis which the parents must resolve constructively, if the welfare of the family is to be safeguarded. Because of the nature of this crisis, and its impact upon the family, the ways in which parents may be helped to adapt to this problem merit special study. The question of institutional or home care for the mongoloid child is a particular issue, since the parents are confronted from the point of the birth, onward, with the decision about how best to plan for their retarded child. Advisors have not always agreed upon which course to recommend, and the professional literature surveyed does not yet furnish consistent and reliable guides in this kind of situation.

Community agencies and state planners are also concerned with providing services that not only foster the optimal development of the retarded child, but that likewise support the mental health of family members. In view of the scarcity and cost of public institutional care, it is essential to know how best to utilize these facilities, so that they may be readily available to those retardates most in need of this kind of service. It is also desirable to prevent institutionalization of those young mongoloid children whose families can adequately care for them at home, especially because recent studies indicate that these youngsters' development may be more fully stimulated in the home environment than in the residential setting (1, 27).

Mongolism, or Down's Syndrome, is a form of congenital defect in which certain physical manifestations are usually identifiable from birth. Slanted eye-folds, flatness of the back of the skull, a tongue which is large and frequently protruding, broad, stubby hands, with incurved little fingers and a single "simian" crease across the palm, are some of the features which may be present in various combinations, along with a tendency toward heart defect and respiratory infection. Mental deficiency is also an accompaniment of mongolism, usually in moderate or severe degree, although there are a few mongoloids who range up to the borderline level of normal intelligence (33). Because the physical and mental deficiencies generally fall within the middle range of severity, mongolism constitutes a distinctive yet fairly homogeneous condition.

Although mongolism represents only one of the many types of mental retardation, it does account for a significant segment (10 to 20 percent) of the diagnoses made in community

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clinics, and comprises the largest single diagnostic entity, as reported by Wunsch (33) and Saenger (25), and according to the experience of the Guidance Clinic for the Retarded in Essex County, New Jersey (1954-1964). The incidence of this congential defect cuts across all social strata without apparent regard for ethnic or environmental conditions, although recent results of chromosomal research point to the presence of a genetic component in a fraction of the births (24).

Since the physical manifestations of mongoloid children are usually identifiable at birth, parents are often faced immediately with the dilemma concerning placement, at a time when they are emotionally shocked and vulnerable to authoritative suggestion or conflicting advice from friends, relatives, or professionals. This tendency of many physicians, as well as other influential persons, to lean almost automatically toward institutionalization as the only solution to this problem creates a need for early decision by the parents. Often before they are able to clarify their confusion, therefore, parents may feel constrained to take a precipitate course of action, rather than arriving at a decision that represents their own desires and best interests. Such premature applications for institutional care may subsequently be disavowed, after the experience of living with the child has disproved the dire predictions of adverse consequences or utter helplessness. Meanwhile, much unnecessary anguish and misapprehension may have been endured. Not only do unwise institutional plans need to be avoided, but parents likewise need to be helped to make application when placement is appropriately indicated.

From the professional point of view there is an increasing search for knowledge about the factors that interact to influence family adaptation to such crisis, as a basis for counseling parents about the placement decision, and for evaluating family strengths. Expanding community programs provide many alternatives to institutional care, which social workers and other helpers may offer to the families being counseled. Therefore, examination of the characteristics, attitudes, and experiences associated with the family's placement intention and level of adaptation may provide guides for effective counseling and community planning.

REVIEW OF PERTINENT LITERATURE

A survey of the professional journals and major publications in the field of mental retardation, over the past decade and a half, revealed considerable interest in the advisability of institutional or home care for children with various types of retardation. But only recently have studies appeared concerning the placement of mongoloid children, specifically, or their impact upon the family. Tizard and Grad (30), Farber (4, 5), and Saenger (25) have made major studies of factors associated with the institutionalization of retardates of various types, and of the effect upon their families. Kramm (17), Giannini and Goodman (8), Kelman (14), and Kugel (18) have focused upon mongoloid children and their families, considering, in part, the question of placement.

Saenger (25) tended to place more emphasis upon the ethnic and socioeconomic characteristics of the New York City families he studied, as factors associated with placement, rather than parental attitudes or other considerations. Tizard and Grad's (30) survey of

London families revealed the importance of socioeconomic factors, along with the availability of adequate community and professional services, in the family's ability to adapt to the presence of the retarded child. Farber *et al.* (5) found interrelationships between "status-maintaining norms and values," the type of family organization, and parental willingness to place the severely retarded child, which suggested that institutionalization helped certain kinds of families to maintain their integration, whereas other families, who kept their retardates at home, experienced adjustment difficulties.

About half of the 50 families with mongoloid children who were studied by Kramm (17) were on an institutional waiting list, and seemed to present a less favorable adjustment picture than did the nonapplicants. Kramm concluded that changes in family organization, as well as parental reorientation to social values, were required to achieve an adjustment to this crisis. In comparing families which included mongoloids with similar units having only normal children, Kelman (14) found no consistently different living patterns or maternal attitudes which would support an automatic recommendation for institutionalization.

The importance of supportive counseling to enable parents of mongoloid infants to reach valid placement decisions was demonstrated by Giannini and Goodman's (8) project, while Goodman (9) spelled out the psychological tasks to be accomplished for sound crisis resolution. Gordon (10) pointed out that adequate parental capacity and accurate information are both essential to stable placement decisions and favorable functioning by families with young mongoloid children.

Kugel's (18) questionnaire study indicated more favorable development by mongoloid children reared at home, in comparison with those who were institutionalized in infancy. Neither his respondents nor the families studied by Graliker (11) considered that the normal siblings had been harmed by the mongoloid's presence, although Farber (4) and Schonell (26) concluded that the retardate often had an adverse effect upon his brothers and sisters.

The variations and contradictions of the available findings, as indicated in this review, emphasize the need for further study to bridge the gaps in knowledge about sound bases for placement of both mongoloid and nonmongoloid retardates. The advisability of studying families in which the retarded child is still present (instead of already placed), has been upheld by Farber (4) *et al.*, Tizard and Grad (30), and others who noted that the family constellation and relationships, before and after the retardate's removal, are not comparable.

PROCEDURE

The population of the study included 103 families who agreed to participate and who met the following criteria: having a mongoloid child under the age of nine years, in the home with both parents, and residing within the northern New Jersey metropolitan area. Fifty of the participating families had applied for institutional care of their mongoloid children, and were on the state waiting lists. The other 53 nonapplicant families were located by intensive case-finding, with the majority being identified through two mental retardation clinics serving the area. Almost 70 percent of those found to be eligible took part in the study. Among the

46 families who did not agree to participate, there was no statistically significant difference between the proportions of applicants and nonapplicants.

Data were obtained directly from the fathers' and mothers' responses to a structured interview schedule, and to paper and pencil attitude and opinion instruments. In addition, the four interviewers,* who were trained social caseworkers with experience in mental retardation, rated the adequacy of each family's functioning in eight areas of family life, according to the specifications of the scale developed by Geismar and Ayres (7). Each family was visited at home when both parents were present and could be interviewed successively by the interviewers, who spent an average of more than three hours per family. The recorded observations of the interviewers, together with the responses of the parents, provided the material from which the principal investigator made independent ratings of family functioning levels, as a check on the interviewers' professional judgment. On only 2 percent of the ratings were there differences of more than one point between the two sets of judgments.

Since it was not possible to conceal the families' application status from the interviewers, the following steps were taken to reduce the bias introduced by this knowledge: *(1)* an equal number of applicants and nonapplicants was scheduled for each interviewer, *(2)* the number of items requiring interviewers' judgment was kept at a minimum, and *(3)* the study provided for direct responses by the parents to objective instruments.

The method of study was by cross-sectional analysis of the differences shown by the data of the applicant and nonapplicant families. In order to increase the fruitfulness of the analysis, the 50 applicant families were subdivided into two groups, according to the degree of parental willingness to place the mongoloid child, as reported during the interview: the placers included 20 families who were eager to institutionalize their retardates, while the remaining 30 families, the postponers, wished to defer placement to some future point. These three groups were then compared, with respect to their responses and the professional ratings, by analysis of variance of the quantified data, using IBM equipment. Correlational analysis was also performed on the data for all families to determine strength of association between the variables, according to Pearsonian coefficients. Data obtained from fathers and mothers were examined in separate but parallel analyses in order to compare their similarities and differences. The scores of both sets of parents on the attitude items were factor analyzed to reduce this body of data to fifteen factors, representing highly intercorrelated groups of responses. The factor scores were included in the analysis of variance and correlational analysis programs.

The major variables examined in relation to parental placement intention (as represented by the two groups of applicants and the third group of nonapplicants) consisted of sociodemographic data regarding the mongoloids and their families; interview responses concerning the parents' reactions, conditions and experiences at the time of the birth and leading up to their placement decisions, as well as reports of their subsequent outlooks; indices of

**All with master's degrees in social work, averaging 38.5 years of age, with an average of 9.75 years of social casework experience, of which an average of four years was spent in working with the mentally retarded.*

father-mother consensus regarding the importance of ten family goals; self-reports indicating the degree of role tension or harmony between each parent and other family members; the Index of Marital (and Family) Integration, after Farber's (3) measures, based upon the two preceding sets of data; the Index of Parental Knowledge concerning mongolism and retardation; self-reports indicating current parental adaptation to the experience of having the retarded child; parental attitudes toward the child's condition, his care, and toward life in general. The professional ratings of family functioning level were examined in relation to placement intention, and also in association with other variables, in an effort to answer the major question of the study concerning the adaptiveness represented by the family's decision regarding care of the mongoloid child.

A limitation of retrospective data, such as that provided by parents in this study, lies in the variations in time of the reports from the point of the crisis, ranging from under one year to over eight years. In an effort to offset these differences, the data were additionally analyzed in relation to families with younger mongoloids (under five) and with the older group (five to eight).*

CHARACTERISTICS OF THE STUDY POPULATION

The mongoloids studied showed a similar ratio between the sexes to that found generally, about 60 percent boys and 40 percent girls, as specified in Wunsch (33), Kramm (17), and in the experience of the Guidance Clinic for the Retarded of Essex County, New Jersey. They were about 4 years old (3.9) on the average. The majority (57 percent) were youngest children and showed a moderate degree of mental retardation (63 percent). The average number of siblings was 2.6, with the largest number being seven.

At the time of the study the fathers were 39 years old, on the average, and the mothers were 37. Most parents had completed high school, with the fathers averaging 13 years and the mothers 12.5 years of schooling. The families were predominantly Caucasian, with only 5 percent nonwhite families included.† All but 12 percent of the parents were native-born, but 31 percent of their own parents were of Italian extraction and 29 percent of Irish background. The majority, 72 percent, were Catholic; 24 percent were Protestant and 4 percent were Jewish.

The majority of the families lived in suburban neighborhoods (66 percent), while 75 percent lived in one-family homes, with an average of 3.2 bedrooms. A large segment of the fathers, 42 percent, were occupied in supervisory, professional, or executive positions. The median social position of the families was lower middle class, according to Hollingshead's (12) weighted Index, based upon the father's education and occupation.

**Editor's Note: Tables in which all data are presented will be supplied upon request.*

†This low proportion may be explained by the fact that the incidence of mongolism is lower among Negroes than Caucasians (31, f.n.), and because the study requirement of intact parental pairs eliminated a number of otherwise possible participants.

In comparison with the characteristics of the general population of the area, the socioeconomic status of the study population was higher. The proportion of Catholics studied was somewhat higher than the 62 percent in the regional population, while the proportions of the other faiths did not vary greatly from the 28 percent Protestant and 10 percent Jewish figures reported.*

The characteristics of the study families differed considerably from those of families studied by other investigators. The present study's age range for the mongoloids was narrower and the mongoloids the youngest, except for Giannini and Goodman's (8) infant subjects. The Catholic proportion was higher than that in other studies cited, while Farber's (5) study families had the highest proportion of Protestants (47 percent) and Saenger's (25), the most Jews (35 percent). The occupational levels of the fathers currently studied were higher than those surveyed by Tizard and Grad (30) and Saenger (25), and the present families were less likely to live in urban neighborhoods.

These differences may well serve to lessen the comparability of the findings of this study with those of the other investigators which have been mentioned.

RESULTS

The situations, experiences, relationships, attitudes, and knowledge of the parents who were studied provided a profile of the significant differences between applicant and nonapplicant families with respect to their original decision and subsequent intentions regarding institutional or home care of their mongoloid children. Since their application status, alone, did not accurately reflect the parents' placement willingness at the time of the interview, it was found productive to subdivide the applicants into two groups, composed of families indicating eagerness or reluctance in their placement intentions. As explained under Procedure, the 20 applicant families falling into the former category were referred to as placers, while the 30 families in the latter group were called the postponers, when being compared to the 53 nonapplicant families.

Sociodemographic Characteristics

The mongoloid children of the applicant families were significantly younger, averaging 3.3 years, than were those of the nonapplicants, whose average age was 4.5 years. This difference was statistically significant at the .01 level of probability. Among the applicants, the postponers' mongoloids were younger than those of the placers, the average ages being 3.1 and 3.6 years. Applicant fathers, as well as mothers, were found to be significantly younger than nonapplicant parents, at the time of the study, with the fathers' ages averaging 37.6 compared to 41.0 years, and the mothers', 35.0 as against 38.6 years (probability less than .05). The placer parents were younger than the postponers, in distinction to the reverse order for the mongoloids' ages.

**Population figures were obtained from the* County and City Data Book *(1962), and religious affiliation totals from the* New Jersey Almanac *(1963), Table 1, p. 654.*

The distinctive difference in the applicant and nonapplicant mongoloids' age distribution had been anticipated, because of conditions encountered in the community during identification of the cases. The practice of deferring admission of most young mongoloid children into state institutions until age 5 or later, resulted in an overrepresentation of these youngsters in the community and on the waiting lists. Likewise, the nonapplicant mongoloids were more likely to be identified after the age of 5, when they become known to the schools, than during their relatively anonymous preschool period. An attempt was made to offset this uneven age distribution by analyzing the data according to families with younger and older mongoloids, in addition to the other comparison groups.

The difference in the mongoloids' age distribution was accompanied by a tendency, significant at the .01 level, for the interviewers to rate those over the age of 5 years as more severely retarded than the younger mongoloids. However, there was no significant deviation by the applicants and nonapplicants with respect to rated severity of handicap, from the moderate degree of the over-all average. However, the severity of the mongoloid's handicap did tend to be associated with parental willingness to institutionalize him and was clearly and negatively correlated with the professional ratings of individual adjustment, and total family functioning.

Although no appreciable differences in sex distribution of the mongoloid were displayed by the applicant and nonapplicant families, interaction, significant at the .01 level, appeared when age and sex of the mongoloid were analyzed jointly in relation to application status and placement intention. A markedly higher proportion of older mongoloid boys, 89 percent, were found among those applicants who were most eager to place them (the placers), while the younger boys were concentrated within the nonapplicant families, with 78 percent. The mongoloid girls were not disproportionately distributed among the six categories of families.

With respect to family income, parents' education, and fathers' occupation, no statistically significant differences were shown between the applicants and nonapplicants. However, when the applicants were subdivided into placers and postponers, and compared with the nonapplicants, significant differences were found in their socioeconomic status. According to Hollingshead's Index of Social Position, the placers achieved the lowest average level, that of lower middle class, while the postponers were rated in the middle class, at the highest level, with the nonapplicants placing in between, toward the upper limit of the lower middle class (.05).

This distinction in social status was supported by the variations of the three groups with respect to the following variables. Only 50 percent of the placers lived in residences, while 83 percent of the postponers and 76 percent of the nonapplicants did. More than half of the placers, 55 percent, lived in urban rather than suburban neighborhoods, in contrast to 27 percent and 30 percent of the postponers and nonapplicants. Only 25 percent of placer fathers were engaged in supervisory, management, or executive positions, compared to 57 percent of the postponer fathers and 40 percent of the nonapplicants. Half of the placers were employed in clerical, sales, or skilled jobs, and 25 percent were pursuing unskilled occupations.

Both of these proportions exceeded those of the other two groups. The median income of the placers was $7,812, compared to $9,167 for the postponers and $8,452 for the nonapplicants.

On other social characteristics the applicants did not differ significantly from the nonapplicants. With respect to education and religion the applicant and nonapplicant groups resembled each other, without statistically significant differences. All five Negro mongoloids studied were under the age of 5 years, the Caucasian preponderance being accentuated by the study requirement that both parents be in the home. In both applicant and nonapplicant families, the majority of the mongoloids were youngest children. The applicants had only slightly more children, 3.7 on the average, compared to an average of 3.5 for the nonapplicants. At the time of the mongoloid's birth the applicant mothers were 31.5 years old, on the average, compared to an average age of 34.0 years by the nonapplicants, the difference not reaching statistical significance.*

Although no greatly distinctive variations appeared in the nationality backgrounds of the paternal and maternal grandparents of the applicants and nonapplicants, a tendency was observed for the placers to be largely of Irish ancestry (45 percent), and for the nonapplicants to derive mainly from Italian backgrounds (40 percent), while the postponers were equally likely to report either of these national extractions (35 percent and 33 percent).

Parental Reactions and Experiences Following the Birth of the Mongoloid Child

A number of significant differences marked the experiences and reactions of the applicants, compared with those of the nonapplicants, which help to explain their application status and current placement intention. The following data were given by the parents in response to the interview questions. It was hypothesized that the more positive the parents' reaction and the more supportive they considered their experiences to be, the less likely they would be to apply for institutionalization.

From the beginning the applicant mothers held lower expectations for the development of their mongoloid children than did the nonapplicant mothers (significant at the .05 level). Those fathers who considered that the information given to them at the time of the birth was helpful tended to report less severe physical-emotional reactions (.05), but most applicant and nonapplicant parents felt that this initial information was not very helpful. The experience of having the retarded child was considered by the applicant fathers to have had considerably more negative impact than by the nonapplicants (.01). Among the applicants the placer father indicated a much greater impact than did the postponers, who signified about the same lower level as the nonapplicant fathers (.001).

Applicant mothers were more likely to blame themselves or their husbands for the child's defect than were the nonapplicant mothers (.05). In addition, these applicant mothers, especially those of the postponer group, incorrectly perceived their spouses' reactions, reporting

**The average older age of mothers bearing mongoloid children has been documented by Penrose (21) and Tizard and Grad (30, pp. 64-65), among others.*

that 42 percent of their husbands were as upset by the birth as they were themselves, whereas only 28 percent of the husbands agreed (.001).

The receipt of significantly more extensive advice favoring placement was reported by applicant parents than by nonapplicants, who had, conversely, been largely encouraged toward home care by the counsel given to them (.001). Most of the placement advice was designated by the applicants as having originated with their physicians, clergymen, and other professionals and with the paternal grandparents (.001). In their initial inclinations regarding type of care for the mongoloid, significantly less agreement was reported by applicant fathers and mothers, who were split 50/50 in regard to home or institutional care, than by nonapplicants, who were 80/88 percent united in their desire to care for the child at home.

Applicant fathers were less accurate in perceiving their wives' initial wishes regarding placement or home care than were nonapplicant fathers (.05). The nonapplicant parents were more accurately perceptive of their spouses' current placement desires than were the applicant fathers and mothers (.05), of whom the placer parents showed the least awareness of their spouses' wishes. Among the applicants the placer mothers indicated that they felt they had received significantly less sympathy and support from their husbands during the birth crisis than was reported by nonapplicant mothers or by postponer mothers (.05).

A more extended period of indecision was experienced by applicant parents, most of whom took seven months or more to decide about application, while the majority of the nonapplicants arrived at their home-care decisions within four months, on the average. Within the applicant group the placers took much longer to decide to apply, averaging nine months to a year, while the postponers reached their decisions almost as soon as the nonapplicants, between four to six months, on the average.

While 76 to 81 percent of the nonapplicants maintained their initial desire for home care up to the time of the study, only 34 to 46 percent of the applicants had not changed from their original intention. Most of the indecisiveness was displayed by the postponers, 77 to 83 percent of whose subsequent placement intentions were different from their original inclinations (.001). Consequently, the more stable placement decisions appeared to be those of the placers.

Extrafamilial Relations and Social Participation

It was hypothesized that parents who considered their formal and informal social relations and participation as helpful and supportive to them in coping with the problems presented by the retarded child would be less likely to have applied for institutional care.

Although the majority of applicant and nonapplicant parents indicated that their usual extrafamilial activities had not been greatly interfered with by the retarded child in the home, significant exceptions were reported by the placer mothers. Sixty percent of the mothers felt restricted in their social activities because of the demands of the retarded child (.001). Applicant fathers were rated by the interviewers as reporting more adequate explanations to their

friends and associates concerning the mongoloid child's condition and outlook than were given by the nonapplicants (.05). The postponer fathers were judged as particularly adept at communicating effectively with their peers on this matter, while the placers were considered to have given more adequate explanations than the nonapplicant fathers (.05).

The age of the mongoloid appeared to have a significant bearing upon the mothers' estimates of the degree to which other people seemed to be accepting of the retardate, whereas no significant difference was shown between the applicant and nonapplicant groups. Mothers of the younger mongoloids (those under 5 years) reported considerably greater acceptance of them by others than was true for the older group (.05). This finding is also related to the interviewers' judgment that older mongoloids were more severely retarded than were the younger group. This interpretation is supported by the inverse correlation which indicated that the less severely retarded mongoloids were likely to be considered by their fathers as more acceptable to others.

In regard to membership in parents' organizations, significantly fewer applicants were affiliated than were nonapplicants (.05), but these two groups were not essentially different in their degree of participation. However, when the applicants were subdivided, and all three groups were compared, the postponers displayed the highest level of participation, the placers the lowest, with the nonapplicants located in between (.05).

The mothers differed significantly in their perceptions concerning the helpfulness of various community services, whereas the fathers' reports did not. Applicant mothers found significantly fewer helpful services than did the nonapplicant mothers (.05). Proportionately more nonapplicant than applicant mothers considered their medical services to have been most helpful. Fewer postponer mothers reported the helpfulness of clinical services for evaluation and guidance concerning mental retardation than did nonapplicants and placers. However, proportionately more of the postponers, along with the nonapplicant mothers, considered the parent-sponsored training programs for retarded children as most helpful, in contrast to the much fewer placer mothers who held this opinion.

In evaluating lacks in community services, the opinions of the fathers as well as those of the mothers varied significantly between the applicants and nonapplicants (.001). Proportionately more of the nonapplicants felt dissatisfied with community educational programs, while the applicants were outstandingly concerned over inadequacies in the public institutional facilities.

Family Goals and Relationships

It was predicted that parents who agreed highly upon the importance of instrumental, rather than expressive, family goals would be more willing to place their mongoloid children. Although no statistically significant differences were found between the two groups of families, the average rankings of the applicants were higher for the instrumental, rather than emotional goals, thus tending to uphold the prediction.

It was also hypothesized that parents reporting a high degree of role tension between themselves, with the retarded child or his normal siblings, would be more likely to institutionalize the retardate than those indicating harmonious relations within the family. While the applicants did not differ materially from the nonapplicants in their reports, comparison of all three groups of families revealed important differences in the mothers' relationship with the mongoloid child, which were statistically significant at the .05 level and supported the prediction. The highest degree of harmony was reported in the relationships between the postponer mothers and their retarded children, with the nonapplicants next and the placer mothers indicating the least compatibility with the mongoloid child. Significant correlations were noted between the mother's compatibility with the retardate and the harmony between the parents and the whole family.

When the age of the mongoloid was considered, it was found that mothers of younger mongoloids reported more harmonious relations with them than did mothers with older mongoloids (.001). Similarly, significantly less role tension between mothers and their normal children was reported in families with younger mongoloids, rather than older ones (.05).

The Indices of Marital Integration and of Family Integration, adopted from Farber (3) and based upon the combined results of parental value-rankings and reports of role tension, failed to differentiate between the applicants and nonapplicants, although they were positively correlated with professional ratings of family functioning.

Parental Knowledge About Mongolism

It was expected that parents who held accurate concepts about mental retardation and who had adequate cognitive understanding of their child's handicap would be less willing to place them than would those with less adequate knowledge.

The scores achieved by fathers and by mothers on the Index of Knowledge, through their answers to twenty statements containing true and false information and concepts about mongolism and mental retardation, affirm this prediction. The postponers and nonapplicants both indicated significantly higher levels of knowledge than did those parents willing to place their mongoloid children, the placers (.001). However, in comparing all applicants with nonapplicants, only the fathers' scores were significantly different, with the nonapplicants revealing the more accurate information (.05).

The parents' scores on the Index of Knowledge were highly correlated with a number of other variables, indicating positive association with fathers' and mothers' participation in parents' organizations, with social status aspects, and with parents' self-reports concerning their own adaptation, as well as with professional evaluation of family functioning. Conversely, more adequate knowledge was found to be associated with less tendency by parents to express attitudes indicative of martyrdom and adverse outlook. The more knowledgeable parents also perceived their retarded children as less inadequate and dependent. The greater the parents' cognitive understanding of their child's condition, the less willing they were to institutionalize him.

Current Parental Adaptation to Their Situations

The prediction was that parents who reported a positive adaptation to the situation of having a retarded child would be less willing to place them that would parents with negative reactions.

The fathers' and mothers' responses to twenty-four statements, which indicated their current reactions to their situations, provided the scores which revealed significant differences between the three study groups, in support of the above hypothesis. The responses of the nonapplicants and the postponers indicated higher levels of adaptation, while both placer parents were significantly lower in their scores (.05). When all of the applicants were compared with the nonapplicants, only the mothers' scores showed a significant difference, with the nonapplicants indicating the better adaptation (.05).

Comparison of the three groups of parents according to the age of their mongoloids revealed significant interaction between the fathers' scores, in the six categories (.05). The placer fathers of younger mongoloids and the postponer fathers of older mongoloids each scored materially lower in regard to adaptation than did those in the other categories, with the placer fathers of older mongoloids occupying a middle level.

Scores indicating the level of parental adaptation were positively correlated with social status variables, as well as with the fathers' degree of participation in church and parents' organizations, with the compatibility of the parents with each other and all family members, with the level of knowledge of both parents regarding mongolism, and with professional ratings of family functioning. Negative associations were shown between parental adaptation scores and their placement willingness, and the cumulative impact of the retarded child. The Index of Parental Adaptation was also negatively correlated with parental attitudes of disaffection toward life, martyrdom, loss of self-esteem and adversity, and was strongly and positively related to parental attitudes indicating resolution of crisis.

Parental Attitudes Toward Life and the Mongoloid Child

The hypothesis proposed that parents who expressed positive attitudes toward themselves, their situations, the retarded child, and child care, in general, would be less willing to institutionalize their mongoloid children than those with less positive reactions. The fifteen factors extracted by mathematical analysis from the fathers' and mothers' responses to 144 statements covering general and specific reactions to child care and their own situations, as well as concepts concerning mental retardation and mongolism, grouped significantly correlated statements together under pertinent subject headings. Five of these factors showed significant differences between the scores of applicant and nonapplicant parents.

Inadequacy of the retardate: The applicant fathers indicated that they perceived their mongoloid children as significantly more inadequate than did the nonapplicant fathers, with the placer fathers revealing the highest degree of this attitude (.05). The stronger the fathers' perception of the mongoloid's inadequacy, the more willing they were to institutionalize them, and the less was their knowledge about their child's condition.

The retardate's potential for socialization: Both groups of applicant fathers (and particularly the placers) saw significantly less opportunity for their retarded children to develop socially through contacts with normal children in the community than did the nonapplicant fathers (.001).

Inseparability of the family unit: The nonapplicant mothers expressed significantly greater determination to keep their families intact than did the applicant mothers, among whom the placer mothers displayed the lowest degree of commitment (.001). The finding revealed by this factor provides an attitudinal verification of the Placement Willingness Index which was constructed to divide the participating families into the three comparison groups.

Peer rejection of the retardate: The responses of all applicant mothers (placers and postponers combined) indicated that they felt a significantly greater expectation that their retarded children would be rejected by normal children in any kind of association, because of the retardates' inferiority, than did the nonapplicant mothers (.05).

Dependence of the retardate: The responses of the fathers as well as those of the mothers indicated that the placers perceived their retarded children as much more dependent than did the postponers or the nonapplicants (.001 for fathers and .05 for mothers). These results support the hypothesis.

The following factors showed significant differences when the families with younger mongoloids were compared with those having older ones. Both of these findings reveal that less positive attitudes were indicated by parents of older mongoloids than by those of the younger group.

Martyrdom of the parents: The parents whose mongoloids were over the age of 5 years displayed significantly greater attitudes of martyrdom than did the parents of younger mongoloids (.05).

Social-sexual incompetence of the retardate: Parents of older mongoloids expressed considerably more concern about their retarded children's incompetence in regard to sexual and marital prerogatives than did those with younger children (.05).

Significant interaction was revealed by the mothers' scores on the two following factors in relation to the applicant and nonapplicant families, subdivided according to the younger or older age groups of their mongoloids.

Inseparability of the family unit: The responses of the mothers of the three study groups, compared according to younger and older age of the mongoloids, indicated significantly varying degrees of commitment to home care of these children (.01). The placer mothers expressed consistently weak commitment to family intactness, those with older mongoloids indicating somewhat less willingness to have the retarded child leave the family circle than those whose mongoloid children were under 5. Among the postponer mothers those with older mongoloids were more committed to keeping their children at home than were the mothers of younger mongoloids and indicated the strongest feeling of all three groups. The greatest difference in attitudes was expressed by the nonapplicant mothers, with those having younger mongoloids displaying the highest commitment to family intactness, while those whose mongoloids were older indicated almost as much inclination toward separation as did the postponer mothers of younger mongoloids.

Dependence of the retardate: The responses of the mothers of the three study groups, according to younger or older age of the mongoloid, revealed interaction which was significant at the .05 level. The highest degree of dependence was perceived by placer mothers of young mongoloid children, while the lowest degree of dependence was seen in older mongoloids by the postponer mothers. Among the two applicant groups of families mothers having older mongoloids considered them less dependent than did mothers with younger mongoloids, whereas nonapplicant mothers perceived them as more dependent. The greatest difference between the views on dependency expressed by mothers with younger, compared to older, mongoloids was shown by placer mothers, while the least difference was expressed by the postponer mothers.

When the responses of all fathers were compared with those of all the mothers, with respect to the fifteen factors, significant distinctions appeared in the following attitudes:

Peer rejection of the retardate: Fathers signified a greater readiness to concede that the retardate could not expect to have friendship and associate with normal children, but instead required segregation, with his "own kind" (.05).

Martyrdom: Fathers displayed more intense feelings of self-sacrifice and self-denial in relation to the retarded child than did the mothers in their responses to the statements subsumed under this heading (.01).

Religiosity: Mothers expressed greater reliance on religious faith and observance to solve the problems connected with their children's handicap (.01).

Disaffection toward life: Mothers indicated a higher degree of guilt, shame, self-blame and resignation in reactions to their situation than was shown by fathers (.05).

Professional Evaluation of Individual and Family Functioning

By means of structured casework judgment the interviewers rated the families according to the anchor points described in the standardized scale developed by Geismar and Ayres (7), covering eight areas of individual and family functioning, and scored on eight points, from inadequate to very adequate. The summated ratings were averaged for an over-all score of family functioning.

It was predicted that families who were judged by the interviewers as showing adequate adjustment and functioning would not necessarily be differentiated by their application status, but would likely be those who displayed adequacy in the following respects:

A high consensus on family goals and values: No significant associations were found between fathers' and mothers' consensus on family goals or values and the professional ratings of family and individual performance.

Low degree of role tension in family relationships: The parents' self-reports, indicating degree of freedom from family tensions, were highly correlated with the professional ratings of the over-all adequacy of family and individual functioning. The parents' reports regarding family harmony were particularly strongly associated with the interviewers' judgments concerning family relationships and integration of all members as a group (.001).

High scores on indices of marital and family integration: The professional ratings of the level of family functioning were positively associated with family scores on the Marital

Integration Index, based upon combined reports, by parents, of their consensus on values and the degree of reported harmony between family members. The interviewers' judgments regarding the marital relationships concurred with parental scores on the Index of Marital Integration, based upon their self-reports.

The parents' combined scores on the Index of Family Integration, which covers relationships between all family members, showed highly positive correlations with the professional ratings of over-all family functioning, and of family relationships between and among members of the group.

Favorable adaptation by parents to their situation: Highly positive associations were found between professional evaluation of all aspects of family functioning and the scores achieved by fathers and mothers on the Index of Current Adaptation, based upon parental reports of current reactions to their situation (.001).

Accurate parental knowledge concerning their child's handicap: The interviewers' judgments concerning level of family functioning were highly correlated with the parents' scores on the Index of Knowledge, derived from their own responses to a set of statements (.001). The fathers' scores indicating adequacy of knowledge were more highly and consistently associated with professional ratings of adequate family relationships and adjustment than were the mothers' knowledge scores.

Applicant–nonapplicant status: While the over-all level of family functioning, as judged by the interviewers, did not differentiate between applicants and nonapplicants, their ratings of individual adjustment and family relationship areas indicated a significantly higher average level for nonapplicants than for applicants (.05). The ratings of these same areas of adjustment and relationship reflected significantly higher levels for families having younger, rather than older, mongoloids (.05). The fathers' adjustment, as evaluated professionally, was significantly more favorable for nonapplicants than for applicants (.05), while the ratings of the other members were not appreciably different for the two groups.

When the applicant families were subdivided according to their current placement willingness, and these groups were compared with the nonapplicants, significant differences were found. The over-all functioning of the postponers was rated as slightly more adequate than that of the nonapplicants, while the placers were rated as considerably less adequate in their total functioning than either of the other two groups (.001). On each of the eight component areas of family life, the placers consistently received the lowest ratings, while those of the postponers and nonapplicants were significantly higher, and averaged close to each other.

While the nonapplicants were judged to have more favorable economic situations, the postponers were rated more highly on their home settings and on their use of community facilities. The family relations of the nonapplicants were evaluated as slightly more adequate, on the whole, than those of the postponers. However, in regard to individual adjustment the postponers enjoyed a slight edge over the nonapplicants with regard to the fathers' and retardates' adjustment, but the nonapplicant mothers were judged as having a more favorable adjustment on the average than was shown by the postponer mothers.

When examined according to the mongoloid's age group, the families with younger mongoloids were rated by the interviewers as functioning more favorably than those with older mongoloids with respect to child care (.05), family relationships (.05), and the adjustment of individual members (.05). These professional judgments concurred with data furnished by

by the parents themselves, indicating greater stress for families with mongoloids over the age of 5 years.

In general, these findings showed concurrence between the professional evaluations of family functioning and indications of adaptation, as derived from the parents' own reports and other data.

DISCUSSION

The differences between the applicant and nonapplicant families furnish material for comparisons with the conclusions of other studies and provide the basis for speculation about the significance of the parents' application decisions and subsequent intentions regarding placement of the mongoloid child.

Sociodemographic factors

Although the mongolids in both groups of applicant families were appreciably younger than those of the nonapplicants, the mongoloid's age, of itself, was not found to be associated with the parents' placement willingness, because of the divergence between the intentions of the placers and postponers, and also possibly since the uneven age distribution was an artifact of community conditions, as explained previously.

However, when the mongoloid's sex was considered along with age, an important indication of the preponderance of older mongoloid boys among the placers pointed to an association between this age-sex combination and parental willingness for institutionalization. The significant segment of younger mongoloid boys found among the nonapplicants also denoted that parental attitudes toward placement of the male mongoloid, in this study, varied directly with his age. It was revealed, however, that parental attitudes toward placement of mongoloid girls was not significantly associated with their age. These findings are more specific than the conclusion of Farber *et al.*, that parents were more willing to institutionalize a retarded boy than a retarded girl. It must be remembered, though, that Farber's subjects were older and included other types of retardation besides mongolism.

One may speculate that in our society the mongoloid boy's limitations become increasingly unacceptable to parents as he passes the normal school age and his discrepancies from the parental expectations for male achievement become more obvious and accentuated. Since the female role in our culture does not demand as much achievement as does the male role (19), parents may therefore be better able to tolerate the inadequacy of the mongoloid girl. This interpretation suggests that the age and sex role patterns of our society are manifested in the differential parental attitudes toward placement of male–female, older–younger mongoloids, as revealed by this study.

The tendency of interviewers to evaluate the younger mongoloids as less severely retarded than those over 5 years of age, concurs with the clinical observations of the author and others, as reported by Fischler *et al.* (6), since the developmental lag of these children

becomes increasingly apparent and measurable as they reach the usual school age. This phenomenon may influence the postponers' placement intentions, since the prevalence of preschool mongoloids in this group may have meant that these parents had not yet felt the full impact of their deficiency and were, therefore, less inclined to consider that placement was needed.

The finding that the majority of the mongoloids studied occupied the position as youngest child in their families agrees with the results of Kramm's study (17) and of Tizard and Grad's survey (30), although Graliker *et al.* (11) found that first-born retardates were more likely to be institutionalized. The tendency of parents to curtail child-bearing after the birth of a mongoloid child was noted by Tizard and Grad (29) as explaining this finding, while Tips *et al.* (29) emphasized the need of these parents for genetic conseling, in view of the wide-spread fear of family taint displayed by married siblings of the affected parents. The absence of significant differences between the three groups of the study, in regard to ordinal position of the mongoloid, did not support Farber's finding (6, p. 58) that mothers were more willing to place the oldest retarded boy than one who was an only child.

Socioeconomic status: The differences in social class position revealed the placers as having the least advantages, compared to the other families studied, with respect to income, occupation, neighborhood, and home setting. However, it should be noted that the variations between the three groups covered a range of only two positions: middle class (the postponers) and lower middle class (the placers and nonapplicants). This difference is not sufficient to reveal a direct association between social class position and placement willingness of the families studied, as has been indicated in the conclusions of Farber *et al.* (5) and Saenger (25). Instead, one must consider a combination of factors in speculating upon what influence they may have had in shaping the parents' placement decisions and intentions.

It seems possible that the postponers' middle-class orientation may have made them receptive to medical and other professional advice at the time of the mongoloid's birth, and therefore may have led them initially to apply for institutional care. However, the placement reluctance subsequently reported by the postponers, and the willingness of the placers, run counter to this postulation, as well as that of Farber *et al.* (5), that parents with higher social status were less tolerant of deviance and more willing to place their retarded children. Consequently, social status alone was not found to be a factor that differentiated between application status or placement willingness of the families studied.

The less favorable circumstances of the placers suggests that their readiness for institutionalization may have had a reality basis, particularly in combination with the younger average age of the mothers and the greater number of children in these families. The fact that many of their mongoloids were approaching normal kindergarten age may also have meant that the placers perferred not to expose their deficiencies to the community, but to remove them through placement. It seems plausible that the placers may have viewed institutional care of the mongoloid as a necessary step to relieve the stress of their situations. Other findings, discussed below, provide more enlightenment concerning this possibility.

As predicted, the applicants' experiences and reactions associated with their original decisions regarding care of the mongoloid child were less positive and encouraging of home care than were those reported by the nonapplicants, and consequently help to explain their attitudes toward placement.

The applicants had received substantially more advice favoring placement, while the nonapplicants had been encouraged by their advisers to care for the mongoloid at home, according to the parents' reports. Tizard and Grad (30, p. 87), as well as Kramm (17, pp. 27-8), also found that parents who decided to institutionalize their retarded children had received a significantly greater amount of such advice than had those who favored home care. Although the sheer quantity of the counsel advocating institutional placement is an important consideration, the susceptibility of the parents to such advice must also be taken into account. The possible influence of middle-class values has already been mentioned as a factor in the applicants' tendency to go along with the placement urging attributed to authoritative sources, such as physicians, other professionals, and paternal grandparents, especially by the postponers. However, there are other indications of vulnerability which also appear to have influenced the decision about home or institution.

The fact that following the mongoloid's birth the applicant parents were less united in their wishes about the child's care and communicated less accurately with one another may have caused them to be more vulnerable to authoritative urging toward institutionalization. In addition, the applicant mothers' less hopeful outlook regarding the mongoloid's development, as well as their greater sense of personal blame for his handicap, may have made them susceptible to placement suggestions. Because of their weaker marital relationship and their lesser ability to withstand the crisis impact, as reported by the placers, the applicants' defense against the urging toward institutional care seem to have been weakened. The strong personal shock of the postponer mothers, along with the lack of security and empathy between them and their spouses, may well have led them to follow the strong suggestions received regarding institutional application.

The applicants also appeared to be especially sensitive to the lack of accurate and adequate information available to them at the time of the birth, as almost uniformly reported by all of the parents, at the time of the interview. Their reports agreed with those of the parents studied by Kramm (17, p. 10), Giannini and Goodman (8), and Tizard and Grad (30, pp. 97-99). The findings emphasize the importance of accurate information about the handicapping condition being made available to parents at the time of the child's birth, since the parents' outlook and attitudes toward care of the retarded child can be greatly influenced by the inadequacy of their knowledge. Since the physician usually informs the parents of the diagnosis and prognosis for the mongoloid child, it is essential that he be able to give accurate medical information in a helpful and sympathetic manner.

The sensitivity of the marital relationship to the assault of a defective child's birth has been pointed out by Cohen (2) and Kozier (16) in descriptions of the self-doubt and guilt

aroused in each partner by such a catastrophe. One may speculate upon the possibility that the greater personal impact felt by the applicant mothers may have made them more receptive to placement advice. However, the subsequent differences between the placer and postponer mothers' willingness to go ahead with placement may have been related to the greater supportiveness which the postponer mothers perceived in their husbands, which encouraged them to care for the mongoloid child at home. On the other hand, the placer mothers may have been discouraged about home care of the retarded child because of the lesser supportiveness and acceptance which they felt in their spouses' attitudes toward them.

The fact that the postponer fathers reported much less negative impact from the experience of having the retarded child is consistent with their reported ability to encourage their wives to cope with the retarded child at home. Conversely, the placer fathers, who reported the highest impact from their experiences, evidently were not able to assist their wives to feel that home care was desirable and feasible.

In contrast to the applicant mothers' vulnerability, the nonapplicant mothers showed more personal stability and considered their husbands to be more sympathetic and supportive, so that together these parents were better able to withstand the impact of the birth crisis and did not need to consider institutional application. The interdependence of the fathers and mothers in resolving the initial crisis and planning for care of the retarded child is shown by these findings.

The greater exposure of the applicants to nonsupportive initial experiences, in addition to the weakness in personal balance and in the relationship between the parents, as indicated above, supported the prediction that they would be more likely to apply for institutional care as an initial step toward resolution of the birth crisis. However, for some of the applicants (the postponers) this early decision proved to be premature, in view of their subsequent change in placement intentions, which may have been fostered by the more positive nature of their intervening experiences. For the rest of the applicants (the placers), whose situations and relationships did not show a similar positive change, their application decisions remained unchanged, since their placement willingness was based upon inability to find ways of resolving the crisis situation.

On the whole, the parents did not consider that the presence of the mongoloid child had an adverse effect upon the normal siblings. There were no significant differences between the average impact of the retarded child, as reported by the applicants and nonapplicants, but the placers indicated slightly more negative evaluations than the other two groups. The moderately positive over-all impressions of these parents tended to refute the dire predictions, attributed to advisers who advocated placement, that the normal children would be adversely affected if the mongoloid child remained at home. Kramm (17) also found that the majority of the parents in her study did not believe that the mongoloid child had a negative effect upon their normal siblings, although the applicants' opinions were less positive than the nonapplicants'. Undoubtedly, the presence of the mongoloid child does result in extra pressures upon the siblings, who need to be helped to understand and deal with this situation in relation to themselves and their peers. If the parents are able to explain and comfortably accept the

retarded child within the family circle, their other children will have an easier time in their adjustment. Otherwise, professional help may be required, either individually or through group participation.

Social Relations and Extrafamilial Activities

The experiences and contacts which followed their initial decision regarding placement also shaped the parents' subsequent plans and intentions toward care of the mongoloid child. In the case of the placers and nonapplicants, their original inclinations (toward opposite ends) were strengthened, while the postponers revised their earlier disposition toward institutionalization. It is noteworthy that fewer applicants than nonapplicants availed themselves of community services which might have supported a plan for home care of the mongoloid child. The importance of adequate and available community services has been emphasized by Tizard and Grad (30, p. 119), who speculated that such help would enable many families to care for their children at home instead of placing them. However, parental motivation to use community services is also a factor, as shown by the differential findings.

The encouragement and assistance which parents' organizations may offer through their community programs and information is indicated by the significantly higher proportion of membership and participation reported by the postponer and nonapplicant parents, who were not currently intending to place their retardates, in contrast to the much lower degree of affiliation and activity of the placers. The quite active participation by the postponers in such organizations, after they had originally filed their institutional applications, may have played a part in their subsequent reluctance to go ahead with placement. The ambivalence suggested by the split in the original wishes of the postponers concerning placement may have motivated them to seek such association, while the placers tended to utilize clinical and counseling services to deal with their more serious adjustment problems. The nonapplicants, who were from the beginning the more united and sure of their interest in home care of their children, gave solid support to the parents' organization through their membership, although they were less motivated to participate as actively as the postponers.

With reference to the use and helpfulness of other community services, the more positive opinions expressed by nonapplicant mothers regarding the medical services they received may well have been related to the greater acceptance and understanding displayed by their physicians, in contrast to the strong advocacy of placement attributed by the applicants to their doctors.

In regard to social activities, Tizard and Grad (30, p. 81) reported that the handicapped child was seen by the majority of the parents they surveyed as a serious restriction. Kramm (17, p. 38) found that many of the families of her study had rechanneled, rather than curtailed, their social activities. In this regard it seems likely that the postponers may have redirected many of their extrafamilial activities into participation in parents' organization programs.

However, the distinctively different social opportunities of the placers and the postponers appeared to be associated with their opposing attitudes concerning placement. The

serious restrictions felt by the placer mothers in their outside activities may have been related to the lack of resources in these families to provide household assistance, so that the mother might be relieved of the constant burden of the retardate's care. Since the placer fathers did not report a comparable restriction in their social activities, the unequal brunt of care born by the mothers may well have had an adverse effect upon their attitudes toward home care of the mongoloid. The lack of mutual consideration between the placer spouses, which is implicit in this finding, also strengthens the suggestion of marital conflict.

The postponers were apparently helped to adapt to their situations by virtue of their more adequate resources and capacities. That the postponer fathers were able to communicate effectively with their associates in explaining the mongoloid's condition, indicated their capacity for accepting and coping with the crisis, while the cumulatively negative impact of the retarded child, as reported by the placer fathers, seemed to be consistent with their unwillingness to sustain a plan for home care. For the postponers the usually nonaccepting orientation of their middle-class social position toward home care of the retardate was apparently offset by the support they obtained from other middle-class parents with similar problems, through their organizational participation.

Parental Self-Reports Concerning Family Goals and Relationships

The lack of significant difference between the father-mother ranking of family goals seems to denote a general similarity in the interests and values of the applicant and nonapplicant families, possibly reflecting the narrow range between their average social class and overall situations. After an average of three or more years of living with the mongoloid child, some leveling off in their social aspirations was perhaps to be expected within all of the study families.

However, the parents' reports regarding intrafamily harmony proved to be sensitive indicators of their desires for home or institutional care of the mongoloid. The mothers' relationship with the retarded child seemed to be the crucial one, since the postponer and nonapplicant mothers revealed significantly greater compatibility with their mongoloids than did the placer mothers. The central importance of the mother's acceptance of the retardate was further indicated by the fathers' reports linking total family harmony with such compatibility.

The finding that mothers of the younger mongoloids signified more harmonious relations with their normal children than did mothers of the older mongoloids has considerable importance for counselors. This possibility of increasing pressure on normal family ties, as the retardate remains in the family, suggests that the effect of the mongoloid's presence in the family should be periodically and carefully assessed, particularly after the age of 5 years.

The failure of the indices of marital and of family integration to confirm Farber's (4, 5) findings in relation to placement willingness and sociodemographic variables probably may be explained on the basis of differences in study populations.

Parental Knowledge about Mongolism

The value of accurate knowledge about the mongoloid child's condition and outlook was revealed by the important association shown between cognitive understanding and parental adaptation to the problems posed by the advent and presence of the mongoloid child. In fact, the acquisition of adequate information emerged as a strong intervening variable between the parents' initial reactions to the birth of the child and their subsequent placement intentions, since the knowledge gained by the postponers appeared possibly to have helped them modify their seemingly premature placement decisions and to withstand the ongoing impact of the child's handicap. Among the nonapplicants, high levels of understanding were also associated with desire to care for the child at home, whereas the placers showed significantly less adequate knowledge. These findings seem to substantiate Mendelsohn's (20) postulation that increased cognitive understanding of mental retardation can have a positive effect upon parental attitudes toward the defective child.

The close association between parental level of knowledge and ability to sustain a plan of home care suggests the effective part which informational counseling could have in helping parents adapt to the crisis situation. The important function of the parents' organizations is indicated by the findings that the better informed parents were those who had actively participated, as well as those who reported the best adaptation to their situations.

Parental Adaptation to the Mongoloid Child

The correlation between the parents' reports of their current adaptive levels and other supporting data, as well as their association with the interviewers' ratings of family functioning, provides a sense of validity for these measures and increases one's confidence in their usefulness. The confirmation of the prediction that parents reporting positive reactions to their situation would be less willing to place their mongoloid children has important connotations for social work practice. The parents' own reports support the concept of social diagnosis with respect to the significance of adequate parental capacities and family resources in coping with adversity. By this token, early casework evaluation of family functioning may provide a fairly good indication of which families should be encouraged to care for the retarded child at home, and which ones might need special support and assistance if they were to be able to meet such additional stress, while still others might be judged to require the lessening strain which the mongoloid's placement could provide.

The finding of significantly lower levels of adaptation by postponer fathers with older, compared to younger, mongoloids, strongly implied that these fathers' tolerance for stress decreased markedly as the child's deviation from normality became more obvious. If such is the case, the superior level of adaptation reported by the postponer fathers of young mongoloids may prove to be only temporary. This possibility raises a question of the extent to which ambivalence and unresolved conflict may be represented in the ambiguity suggested by the placement reluctance of these applicants. These fathers may not simply have shown planfulness in regard to the future, but instead may have been unable to resolve their conflicted feelings about themselves, the mongoloid, and their situation.

Parental Attitudes Toward Life and the Mongoloid Child

The attitudes represented by the factors depicting parental perceptions of the retardate's deficiencies evidenced the less positive outlook of the applicants. The applicant fathers were more sensitive than nonapplicants with respect to the mongoloid's inadequacy and social incompetence, while the applicant mothers showed more concern about his rejection by other children and about the question of maintaining the family circle. It appeared that these parents' attitudes were characteristic of their sex roles in life, with the fathers focusing upon incapacities preventing the mongoloid from normal development and performance and the mothers expressing their maternal feelings. Thus, the placement willingness of the mothers reflected their personal, expressive reactions, while the fathers' concerns were of a social and instrumental nature.

The attitudes held by both fathers and mothers toward the retardate's dependency varied more strongly in relation to the mongoloid's age than in regard to application status or placement willingness. Since the nonapplicants' view of their older mongoloids as more dependent than their younger ones was the reverse of the applicant parents' perceptions, one may speculate that the nonapplicants felt freer to appraise their mongoloids realistically than did the applicants, in view of the tendency, shown by the study results, for the older mongoloids to be rated as more severely handicapped than the younger ones.

The more adverse impact on parental adjustment, suggested by the less wholesome attitudes expressed by parents of older mongoloids, supports the advisability of careful, periodic review of parental capacity for withstanding the stress of home care of these retardates. If supportive assistance cannot sufficiently improve the parents' coping capacity, placement of the mongoloid may be necessary to relieve the pressures of his care and prevent the development of pathological reactions, such as martyrdom, by the fathers, or maternal anxiety over the retardate's social and sexual incompetence.

Knowledge about the specific areas of parental sensitivity and reactions toward the child's deficiencies, as brought out above, may alert the counselor to explore and clarify these attitudes.

Professional Evaluation of Family Functioning

The significantly higher professional ratings given to the nonapplicants in the areas of family relations and with respect to the fathers' individual adjustment indicate the importance which the interviewers attached to these aspects in regard to home care of the retarded child. This emphasis upon the father's adjustment as a major factor in relation to application or nonapplication agreed with the indications of the interview data. On many other areas of family functioning, however, distinctive differences were shown only when the ratings were examined according to the families' placement willingness.

The consistent professional judgments that the lowest levels of functioning in all areas of family life were shown by the placers agreed with these parents' self-reports of over-all

adaptation as well as with the indications of other data. Consequently, there seems to be little question that these families, who were most eager to place their mongoloid children, were the least adequate of those studied, according to their own views, as well as in the judgment of others. Still, it must be remembered that the over-all functioning of this group of families was above marginal and averaged just below the near-adequate level.

Although, on the average, the postponers and nonapplicants were rated close together, at a near-adequate level, their areas of difference were significant. The postponers' greatest strength was judged to lie in their social, extrafamilial, community, and child-centered aspects. In contrast, the greater adequacy of the nonapplicants was focused on their personal, close relationships within the family unit itself. The emphasis of the postponers' functioning might be characterized as "other-directed," and the nonapplicants, as "inner-directed," in Riesman's terms (23).

The strongly positive correlation between the parents' level of knowledge about mongolism and the professional ratings of family functioning provides another confirmation of the importance of adequate parental information for satisfactory adaptation to the stresses of having a retarded child in the home.

Over-all, the findings revealed the interaction of social, cognitive, experiential, attitudinal, and relational factors in the application decisions and subsequent willingness of the parents concerning institutional or home care of the mongoloid retarded children. The influence of the age and sex of the mongoloid upon parental placement intentions, and upon adaptation to the stresses of living with the handicapped child, as indicated by the study results, call for professional evaluation and the extension of social supports to the family at crucial stages in the child's life, such as that between 5 and 8 years of age.

The critical influence of the experiences reported by families as occurring immediately after the mongoloid's birth indicated the importance of adequate counseling and information during the initial crisis, as well as subsequently. The apparent effectiveness of cognitive understanding as an aid to parents in withstanding crisis and in arriving at sound decisions is one of the most important findings, with definite implications for counselors, physicians, and community services. The family relationship was located as the most sensitive area of family life, in regard to plans for home or institutional care of the mongoloid child, as well as with respect to subsequent adjustment of the whole family. The essential contribution of the father was seen as his support and encouragement to the mother through his capacity to withstand the impact of the crisis and subsequent stress. The influential feelings and attitudes of the mother regarding home or institutional care were revealed to be dependent upon the nature of her relationship with the father and to affect the welfare of the children. The interrelationship of paternal and maternal characteristics and attitudes, as observed in the findings, pointed up the necessity to consider the reactions and needs of both parents in helping the family meet and deal with crisis.

While the results of the study supported the findings of other investigators, such as Tizard and Grad (30), Kramm (17), and Giannini and Goodman (8), the differences between

the population studied here and that included in Farber's (5) and Saenger's (25) investigations decreased the comparability of the conclusions. While current findings did not show social status and religion to be differentially associated with placement willingness, age and sex of the mongoloid were found to have a specific relationship.

CONCLUSIONS

Perhaps the outstanding finding of the study was that their application status did not accurately describe the subsequent intention of 60 percent of the applicants with respect to placement. The breakdown of the applicants into two groups with quite different degrees of placement willingness produced fruitful distinctions from the data analysis which provide the basis for evaluating the nature of the different outcomes.

The summary profiles provided by the findings, with respect to the three study groups, present distinctive factors associated with the parents' application decisions and their subsequent willingness or reluctance to institutionalize the mongoloid child.

The placers' consistently strong desire to institutionalize their retarded children appears to be understandable and necessary, in view of their less favorable situations, relationships, personal balance, knowledge, and experiences. These parents participated the least in supportive extrafamilial associations and found little help from community services. Not only was their uniformly lower average level of adaptation indicated by the parents' own reports, and by the professional ratings of family functioning as well, but this evaluation was also supported by objective sociodemographic data and cognitive measures and by indirect attitude expressions. This consensus of opinion regarding the poorer resources and adaptive achievement of these placer families is impressive and points to the conclusion that they were not able to absorb the mongoloid child into their family circles without adverse effects. Unless it were possible to improve the functioning of such families by social work intervention, through offering community services to bolster their coping capacities, their presenting situations seem to require relief from strain of the mongoloid's care which placement would afford. With such lessening of the strain of the mongoloid's presence and care, these families might then have sufficient resources to bring their functioning up to a more satisfactory level.

The picture drawn by the findings concerning the nonapplicants depicts their consistently stable desire to care for their mongoloid children in the home, and also reveals their generally adequate situations, resources, and parental capacities for constructively coping with the crisis and stress of the handicapped child. The agreement between the professional evaluations and the parents' self-reports, as well as the corroboration of other objective and projective data, supports the conclusion that the nonapplicants, on the whole, were able to absorb the retarded child into their ranks without appreciably adverse consequences for the family members, despite the older average age of their mongoloids. Therefore, their nonapplicant status and unwillingness to place their mongoloid children appear to be consistent with their coping capacities, and may be considered appropriate.

The postponers' profile shows many positive aspects, but also contains some contradictions, which suggest that for them the crisis situation has not been wholly resolved. The fathers in these families revealed considerable personal strength in their ability to withstand the impact of the birth and to support and encourage their wives, as well as to relate effectively to associates outside the family. However, their susceptibility to the urging by authoritative sources, resulting in premature and unstable institutional application, suggests a lack of emancipation from parental ties at the time of the mongoloid's birth. The postponer mothers' strong feelings of personal blame for bearing a defective child resulted in marital insecurity, since they seemed to feel unworthy of their husband's regard and believed their husbands were disappointed in them. These postponer couples were not united in their wishes regarding the child's care at the time of their application decision. Since they received little help from community or professional sources in clarifying and resolving their natural conflict and ambivalence at this initially crucial point, it is not surprising that the application did not represent their stable wishes in regard to the child's care.

Subsequently, however, the enlightenment and encouragement which these parents sought and found from association with other parents having similar concerns appear to have influenced them to modify their original placement intention and encouraged them to postpone institutionalization. Despite the currently satisfactory adaptation reported by the postponers whose children were of preschool age, the significant indications of much less satisfactory functioning on the part of those fathers with older mongoloids strongly suggests that the emotional ambivalence of many of these parents had not been resolved, but only compromised, through postponement of their decision regarding placement or home care. Unless these parents are able to deal more squarely with their feelings and settle the issue of ultimate plans for the mongoloid's care, severe strain from the increasing pressures of the older retardate's presence may well affect the functioning of the fathers, in particular, as well as the rest of the family.

These interpretations were supported by the professional evaluations, which indicated weakness in familial relations, and in the postponer mothers' adjustment, in comparison with the functioning of the nonapplicants. Otherwise, however, the postponers were judged as showing social and environmental aspects in their family living. In view of their many positives and their few important weaknesses, the postponers may be viewed as families in transition from an initially premature application decision toward greater awareness and cognitive understanding. Since they have only postponed placement, it appears that they have not yet completed the resolution of the conflicts which would enable them either to withdraw the institutional application, or to decide definitely upon placement. It is to be expected that many of these parents will eventually solve their ambivalence, especially if they obtain competent counseling and do not rely entirely upon their own cognitive awareness and supportive associations. Others, however, may experience increasing impact and pressures which may affect their functioning adversely, as the mongoloid grows past the preschool period, and their basic ambivalence persists.

Despite their statistically significant differences, the three groups of families studied above showed fairly good over-all functioning, averaging from above marginal (the placers) to

near adequate levels (the postponers and nonapplicants). In view of their general similarity, it may be fruitful to examine the factors which appear to have influenced their initial decisions concerning institutional application and those which may explain their subsequent outlooks regarding placement.

In regard to initial decision about type of care for the mongoloid child, the results clearly indicated that the nature of the parents' experiences and relationships had more influence in determining whether or not they would apply for institutional care, than did their social, situational, or personal resources. These findings revealed that the applicants received much more advice urging placement, held less hopeful outlooks for the mongoloid child's development, reported less unity, closeness, and security between the marital partners, and generally felt less encouraged to undertake the strain of having a handicapped child in the home, than was true for the nonapplicants.

However, after this initial decision regarding application was reached, the influence of personal, social and situational differences was reflected in the contrasting outcomes for the applicants, in terms of their continued willingness or reluctance to go through with institutionalization. The process of living with the mongoloid child revealed that the placers' personal capacities and social resources were less adequate for withstanding this stress than were those of the postponers, who found more supportive associations, were motivated to gain more accurate knowledge about their child's handicap, and were able to adapt more favorably to their situations.

One may speculate that the placers might have been helped to make a more satisfactory adjustment if the community had provided more adequate services to give them the extra personal, informational, and social supports needed to offset the impact of the retarded child upon the family's own resources for coping with crisis. It seems possible that such social intervention, beginning at the time of the mongoloid's birth, might have enabled some of the placers to absorb the child into their family circles, rather than becoming discouraged to the point of wishing to place him in order to relieve the pressures of the situation. While the many factors, which no doubt also influenced the intentions of these families, would need to be considered on an individual basis, the broad outlines drawn above depict important areas within which families may be helped to cope more successfully with the crisis and continuing strain of having a congenitally defective child.

IMPLICATIONS AND RECOMMENDATIONS

The results of this study contain significant implications for professional practice and preparation, for the provision of community services and public information, as well as for further research investigation.

In regard to professional practice, the importance of accurate information and sound counseling services being made available to parents at the time of their greatest stress, during the birth crisis, has been emphasized. One of the primary tasks which parents must accomplish, if they are to cope successfully with the impact of a congenitally handicapped child, as

specified by Goodman (9) and Rapaport (22), is to face and deal with their own shocked reactions and conflicted feelings which are inevitably engendered by such personal catastrophe. The properly prepared social worker or other counselor can facilitate the resolution of this conflict through sensitive exploration and skillful clarification of the parents' reactions and desires.

Since at the time of the greatest need parents are most accessible to helping services, social intervention can be particularly effective during the birth crisis. Immediate counseling should be offered without waiting for parents to seek it out. Parents also need to be informed about community resources and alternative plans to placement. Such enlargement of the parents' repertoire for meeting crisis can help to prevent their being stampeded into precipitate or unsound institutional application. The kind of help which is appropriate during this initial phase is intensive short-term counseling, which offers both tangible and subtle assistance.

If parents are to receive such help at the time and place it is most needed, the hospitals will have to provide more adequate social services than are usually available. At the birth of every child with a recognizable congenital handicap, the services of a competent social worker should be made available to the parents, regardless of whether they are clinic or private patients. Rather than relying solely upon the physician to provide or request such guidance, the particular skills of the social worker might well be utilized in helping parents to meet the initial crisis. Through joint counseling the physician and social worker, together, could be doubly effective in providing authentic information and enabling support to the parents. It is believed that most physicians would welcome the assistance of a competent counselor in helping the family with continued planning.

The way in which the physician can be of the greatest help to parents during the birth crisis is by giving accurate medical information about the child's condition and outlook, in a manner which is sensitive to their vulnerability and impaired self-regard. Consequently, it is important that advice concerning placement be deferred for consideration at a later time with a consultant who is especially knowledgeable about such planning. In recognition of parental fears of producing other defective offspring, the physician can perform an essential service by arranging for chomosomal analysis and genetic counseling, at an early point following the birth.

In order to serve the mentally retarded, all of the disciplines require special professional preparation, which needs to be strengthened. To develop competence in dealing with the problems of mental retardation, physicians, social workers, nurses, and other counselors must have knowledge beyond the fundamentals furnished by the basic professional education. To this end, postgraduate seminars and training opportunities need to be made available through the combined efforts of the national programs and the professional organizations concerned with mental retardation.

After the initial crisis is resolved, parents need less intensive help and may then be ready to utilize other community resources which offer supportive services. The public health nurse can provide valuable guidance and information concerning the retarded child's training

and course of development. Association with other parents in the programs of such organizations has proved valuable in providing encouragement and enlightenment to parents concerning the possibilities for home care and community training of the retarded child.

Because of the permanent nature of mental retardation, there is a need for parental counseling and guidance at critical points in the retardate's life cycle. Periodic reassessment at these times is important to determine whether changes in planning and readjustments are indicated in order to foster sound family functioning. The recurrent nature of the guidance needed by parents with retarded children calls for the location of such services at a fixed point of reference, where permanent records of the child's progress may be kept, and consultation about changing situations and appropriate resources may be provided. Recent demonstrations in Los Angeles and Rhode Island have indicated the helpfulness of such information and guidance centers, so that, as they feel the need, the parents may turn to a familiar source for evaluation or guidance. These centers may also become the focus for integrating services for the retarded with other community programs and for highlighting unmet needs.

In addition to these specific suggestions about community services, over-all planning is essential in order to extend and improve existing facilities and to develop new programs to cover the full range of services required by parents and retarded children. Parents' organizations can make a signal contribution by entering into fruitful partnership with the voluntary and public community networks, thereby sparking the development of more complete and adequate diagnostic, guidance, medical, recreational, vocational, and other services for the retarded.

In order to minimize the possibility of premature institutional application and admission of mongoloid babies, the parents' initial inquiry into the state admission department should set into action a process of immediate and careful screening of the request, along with diagnostic evaluation and guidance, and information about alternative plans for coping with the problem. By such early and careful study, the families needing institutionalization might be assured of prompt admission, while other families could be enabled to care for their mongoloid children at home, through the help of the community services made available to them.

The effectiveness of adequate and accurate information in helping parents to cope with the presence of a retarded child has been emphasized by this study. However, in many situations this knowledge was sought and acquired only after unsound steps had been taken. In addition to the information which may be furnished through individual counseling at the point of crisis, parents may be prepared, to some extent, by general knowledge about mental retardation and community programs for dealing with its problems, through public informational campaigns. Currently, the national and local support for the development of better understanding by all citizens of the nature and means of dealing with mental retardation seems hopeful.

Further Research Needs

The present study represents a begininning inquiry into the problems faced by families with congentially defective children and points up the need for more extensive investigation. While meaningful results have been produced by this project, the limitations of the retrospective, cross-sectional method of study call for further prospective, longtudinal investigation of the problem. Systematic examination of the patterns of family response to this and similar types of birth crisis, as well as evaluation of the effectiveness of various techniques of social intervention, can most profitably begin at the time of birth and continue over a span of time, with periodic follow-up and assessment. In this way the indications growing out of the present study might be tested to determine their broader applicability to nonmongoloid and other kinds of crisis situations.

Specifically, such study would have to cover a sufficiently large number of families to provide variation in their socioeconomic and ethnic backgrounds and could be drawn from the newborn population of a group of metropolitan hospitals or a medical center. Other types of birth crisis, such as that precipitated by prematurity, as well as family response to normal births, should be studied for purposes of comparison with the impact of neurological and sensory birth defects, such as blindness, cerebral palsy, and hydrocephalus, in addition to mongolism. The methods and instruments which have been developed by public health investigators of crisis response and intervention, such as Hurwitz (13), could be utilized for assessment of family strengths and coping mechanisms. The realization of such a project would entail the joint efforts of community and professional groups, such as the health and hospital council, the public health departments, the medical society, nursing organizations, as well as the cooperation of other professional and parent groups. Soundly designed and executed, this kind of study project could point the way to improved methods by which the community might foster the welfare of families and children faced with a range of birth crisis.

Dissemination and Utilization of the Findings

Besides utilizing the results of this study in planning further research, their effectiveness may be increased through presentation and interpretation of appropriate, concerned community groups. Certainly, the parents of retarded and other handicapped children should be vitally interested in learning about findings which may help others to cope with similar problems. The medical, nursing, and social work professional societies need to be made aware of the guides to practice which emerge from this investigation and which may serve to stimulate practitioners and counselors to find more constructive ways of helping the parents who look to them for advice and guidance. If the helping services are to be brought to the families at the time of the birth crisis, hospital staffs will need to be informed of the findings which point up the current gaps in provision of such assistance and stimulated to meet these needs more adequately.

Through effective presentation of the study results and implications for service, community organization bodies might be stimulated to develop a pilot program which would embody both demonstration and study of helping methods, as suggested above. Finally, wide publicizing of the study findings and recommendations should help to educate the general public about situations which they or their neighbors might well encounter.

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It is my hope that the cumulative efforts of so many persons will have achieved the primary goal of this study, to learn how better to help families meet and deal with the crisis of having a mongoloid retarded child.

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